OOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

INDO-PACIFIC FISHERIES COUNCIL

PROCEEDINGS

7th SESSION

BANDUNG

INDONESIA

13—27 May 1957

SECTIONS II AND III

IPFC Secretariat, FAO Regional Office
for Asia and the Far East
Bangkok
1958

The full PROCEEDINGS of the 7th Session consist of three sections, of which the second, Technical Papers, and the third, Symposium Papers, are contained in this issue. Section I comprised the Report of Proceedings.

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ON THE USE OF MARYGOLD *(TITHONIA DIVERSIFOLIA* GRAY) AS GREEN MANURE IN INDONESIAN CARP PONDS*

by

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ABSTRACT

A series of experiments with *Tithonia diversifolia* Gray was carried out in order to ncrease the yield of *Cyprinus carpio* L. It was concluded from investigations concerning ield, the biota of the ponds and the gut contents of the fish, that maximal increase n yield is obtained by manuring in the inflowing water, in ponds stocked with fry of the Common carp together with large, male *Tilapia.* An explanation was sought in the direct nfluence of the large development of Oligochaetae among the decomposing vegetable natter and in the indirect effect of liberation of minerals caused by the decomposition. Algae, such as *Spirogyra* encouraged by the organic manure not digested by zooplankton nd of limited nutritional value for the carp, were eaten by the *Tilapia.*

The maximal increase in yield was obtained by manuring with 6.8 ton *Tithonia* er hectare per month at a stocking rate of 50,000 carp of 1.3 gram and 6,800 *Tilapia* of 3.6 gram. The increase in yield, caused by *Tithonia,* amounted to 85 kg. carp and 39 kg. *Tilapia* per hectare per month.

INTRODUCTION

At a suggestion of the Head of the Labory for Inland Fisheries, Bogor, H. Saanin, a of experiments was carried out with green ure in carp ponds, with the aim of increasing total yield. In Indonesia, where fertilizers expensive and rare, it seems desirable to use dly growing, easily obtainable weeds as en manure. Marygold (*Tithonia diversifolia* y) being abundant even on poor soils and ly decomposable as well, it was decided to this plant, as an example of suitable green ure. Van de Goor (1952) reports that the ue of *Tithonia* as green manure on paddy ds almost equals that of the legume *Crotalaria ramoensis* Bak. A chemical analysis of the nt, kindly carried out by Prof. Dr. L. W. leman at the Laboratory of Inorganic Chetry of the Faculty of Agriculture of the iversity of Indonesia at Bogor, gave the owing results:

-dry material:	*Percentage*		
Dry weight	15%		
Moisture	85%		
Total minerals in dry material:	12.2% =	MgO	0.8%
		CaO	1.9%
		K_2O	5.1%
		SiO_2	1.2%
		PO_4	1.0%

EXPERIMENTS

In a preliminary experiment (No. I) carried out in collaboration with Kartina Tazar, 4 concrete tanks, with a surface of 18 m^2 each, were stocked with 15 carp, weighing about 21 g. each. Out of 4 tanks, 2 were manured with 1 kg. *Tithonia* each day.

The yield* *, obtained after 1 month, was 101.4 g. and 108.0 g. for the manured tanks 50.4g. and 70.0 g. for the controls. So, the increase in weight, obtained from 30 kg. of *Tithonia,* amounted to 51.0 g. and 38.0 g., the average increase in weight from 1 kg. of *Tithonia* being 1.5 g.

It was inferred from limnological investigations, carried out regularly during the period of growth, that phytoplankton, mainly the Chlorococcale: *Dictyosphaerium* was far more abundant in the manured tanks. No differences were observed in the numbers of Chironomidae.

The preliminary conclusion was that manuring chiefly increased the development of phytoplankton.

A second experiment (No. II) was carried out in six ponds, with a surface of 200 m^2 each,

* Compilation in English of the Reports of the Laboratory for Inland Fisheries, Bogor, No.: 10, 15, 16, 17 by authoress.

** Yield always means increase in weight, *viz.* cropping weight minus stocking weight.

with a duration of three periods of 1 month. The results are presented in Table I. Biota from the mud and from the water were investigated weekly. No differences were found in the numbers of Chironomidae in the mud, phytoplankton seemed to be a little more abundant in the water of the manured tanks, and o bottoms of the manured tanks algae occ in conspicuously higher numbers. Ofte outburst of *Spirogyra* was also noted in ponds.

Table I. Experiment II. Effect of manuring with *Tithonia* on the yield of the pond.

Period	Number stocked	Total weight stocked (g.)	*Tithonia* (kg.)	Total yield per month (g.)	Increase due to *Tithonia* (g.)	Increa per k *Tithoni*
I	1,000	150	30	2,215	260	8.5
	1,000	160	60	2,492	537	9.0
	1,000	155	—	1,955	—	—
	500	1,360	30	1,780	160	5.3
II	500	1,345	60	1,995	375	6.3
	500	1,365	—	1,620	—	—
	250	1,410	30	2,025	405	13.5
III	250	1,450	60	1,985	365	6.1
	250	1,445	—	1,620	—	—

The gut contents of the cropped carp were examined by Dr. K.F. Vaas. The volumes of food organism, expressed as percentages of the total contents of the gut, are given in Table II. With a single exception—60 kg. manure, first period—the volume of Chironomidae was higher in all control and more filamentous algae were encountered in the case of the carp from manured ponds. These differences being slight, it may be inferred that *Tithonia* is r decomposed—visual proof of this decompo being easily obtained—and rapidly inserte the normal metabolic cycles operating i ponds, which cycles do not seem to be ch but only intensified by the addition o organic substance.

Table II. Experiment II. Volume of food organisms in the guts of four carps expresse in percentage of the total volume of gut contents.

Biota \ *Tithonia* (kg.)	First period (Days)			Second period (Dags)			Third period (D	
	0	30	60	0	30	60	0	30
Chironomidae	1,400	28.3	9.4	1.8	6.0	6.3	2.0	16.7
Other Insects	2.0	15.1	5.6	4.9	1.5	12.7	2.0	10.7
Cyclopidae	83.2	56.0	86.0	68.0	54.0	53.7	87.0	50.0
Cladocera	1.0	—	0.3	11.8	3.6	15.8	6.5	13.3
Oligochaetae	—	0.3	—	—	—	—	—	—
Thread algae	—	0.5	—	14.0	35.8	11.5	2.5	9.1
Number of carp	8.0	8.0	8.0	4.0	4.0	4.0	4.0	4.0
Total length of carp (cm.)	4.6—7.2	5.6—8.1	5.5—7.5	7.2—8.0	7.1—8.4	5.7—8.5	9.0—9.7	8.8—10.5

The regular additions of *Tithonia*, for ıe time floating on the surface, seemed to ·act adult Chironomidae, as was mentioned Sadler (1955) and Wirzhubski (1952), and) confirmed by preliminary experiments in hatchery at Bogor. Another influence of green manure seems to be an encouragement *Spirogyra*. Although small amounts of this ae are ingested by the carp, a large portion is ·ays left uneaten and thus minerals are being de tracked". Large masses of *Spirogyra*) make the draining of the pond difficult.

A third experiment (No. III) was carried by R. Slamet Soeseno, under the direction the author, in the tanks used for the first ıeriment.

Two hundred kg. of *Tithonia* were permitted to decompose in smaller concrete tanks—surface 9 m^2 —not stocked with fish, and situated in the immediate vicinity of the fish tanks. Organisms developing during the decomposition of the green manure were indentified and counted, and 2 weeks after decomposition had set in, four experimental tanks were stocked with 15 carp each, weighing 14.2 g. in average. Two of these tanks were given 1 litre of the decomposed mass of *Tithonia* daily. After 1 month the tanks were cropped and restocked with 15 carp, weighing 24.4 g. each, on average. At this stage, part of the tanks were given a dose of 2 litres decomposing *Tithonia* daily. Cropping took place after 1 month. Results are shown in Tables III and IV.

ole III. Experiment III. Effect of manuring with decomposed *Tithonia* on the yield of the pond.

Period	Number stocked	Total weight stocked (g.)	Amount of manure (kg.)	Total yield in one month (g.)	Increase due to *Tithonia* (g.)
I	15	220	30	170	25
	15	210	—	145	—
II	15	355	60	135	10
	15	370	—	125	1

Although a large number of organisms table as food for the Common carp had deoped, the increase in yield, obtained as a ult of the manuring, was insignificant. wever, it is evident that this time the controls duced much more fish than the controls in the previous experiments, (Experiment I) stocked at comparable rates. This might indicate that adult Chironomidae were attracted by the decomposing vegetation and induced to lay their eggs, in the neighbouring, unmanured tanks as well as in the small tanks with *Tithonia*. As

Table IV. Experiment III. Organisms developing in decomposing *Tithonia*.

Biota \ Week	1	2	3	4	5	6	7	8	9	10
vae (*Eristalis, Culex* etc.)	+++	++	+	+	+	+	+	+	+	+
ytoplankton	+	+++	+++	+++	+	+	+	+	+	++
otozoa	—	—	+	++	+	+	+	+	+	+
ifera	—	—	++	+++	++	+	+	+	±	±
istacea	—	—	—	+	+	+++	+	+	+	+
varsus larvae	+	+	+	+	+	+	+	+	+	+
lumesus larvae	—	±	±	±	++	+	+	+++	+	+
	Used as manure in first growing period.					Used as manure in second growing period.				

this method of separate decomposition of green manure needs extra space and will attract noxious mosquito larvae as well as Chironomidae, it can not be deemed a successful one.

The fourth experiment (No. IV) was carried out in collaboration with N.R. Harahap, Abdul Rachman, Suherman and Much. Machfud.

Six small ponds with concrete walls and sandy bottom were used (surfaces respectively 46 and 20 m^2). A constant, slowly running supply of water of about 1 litre/sec. for each pond was maintained. At the inlet a small semicircular bamboo screen was constructed and filled daily with *Tithonia* in various amounts.

The ponds were drained after one r and the carp counted and weighed. Sa of netplankton, nannoplankton and b samples were taken from the ponds as as from the decomposing *Tithonia*, immed prior to the draining. In the first exper of this group (IVa) no gut contents examined. Samples of the guts taken the three following experiments (IVb, c were examined by Dr. K.F. Vaas, in the way. The results of experiment IVa are in Tables V and VI. A marked increa total yield of carp was observed.

Table V. Experiment IVa. Effect of manuring with *Tithonia*, decomposing in the inflow water, on the yield of ponds stocked with *Cyprinus*.

Surface of 2 ponds (m^2)	Number stocked	Total weight stocked (g.)	Total amount of *Tithonia* (g.)	Total yield in one month (g.)	Increase due to manure (g.)	Incre per k *Tithonia*
66	525	760	—	95	—	—
66	525	740	22.5	195	100	4.4
66	525	735	45.0	255	160	3.6

In this experiment *Spirogyra* was most abundant in the manured ponds and, for that reason development of phytoplankton was lower than in the controls, because minerals sto the threads of *Spirogyra* were unavailable plankters. Both phytoplankton and zoopla were more abundant in the controls. The ber of Oligochaetae and Chironomidae i ponds proved to be independent of the a of manure. However, within the ba screens, Oligochaetae were found in number in the decaying *Tithonia*. The species found here, was *Aulophorus fu* (Oken), found only occasionally in the and in the inlets. So, the decomposing *Ti* seems to be a selective environment su for the development of this worm.

Table VI. Experiment IVa. Effect of manuring with various amounts of *Tithonia* on the biota of ponds stocked with *Cyprinus*.

Biota \ Amount of *Tithonia*	0	22.5	45
Phytoplankton, Number/l.	7,200	4,750	6,525
Spiragyra, mg. dry weight/l	3.4	76.0	35.2
Rotifera, Number/l.	1,325	350	500
Crustaceae, Number/l.	3,500	925	800
Oligochaetae in bottom of pond, Number/24 ml.	7	2	3
Chironomidae in bottom of pond, Number/24 ml.	1	2	0
Oligochaetae in *Tithonia*, Number/24 ml.	—	57	316
Chironomidae in *Tithonia*, Number/24 ml.	—	3	4
Diatomeae in bottom of pond, Number/24 ml.	109,000	138,500	157,000

Contrary to expectations based o results of Experiment III, very few Chirono only were encountered inside the ba screens.

Very often carp were observed to near the screen and small carp quite ventured inside. It may be assumed tha inflowing water carries small bits of decomp *Tithonia* with worms into the pond and t creased yield must be due, to a large exte the constant supply of such small worms no gut contents could be examined this no confirmation of this assumption can be As the accumulation of *Spirogyra* does not to be advantageous, another experiment

ied out in the same ponds, trying to eliminate *ogyra* by introducing male *Tilapia mossam-* P. with the carp. *Tilapia* is a vegetable ler and a prolific spawner. This mouth- der tends to create automatically a situation verstocking in ponds and, for this reason, noculture of the larger males was indicated in case (Vaas and Hofstede, 1952). It was experimentally proved that an appropriate stocking of *Tilapia* in brackishwater ponds is able to suppress, a bloom of filamentous algae (Hofstede and Botke, 1950). In this preliminary experiment (No. IVb) no *Tithonia* was given. When the ponds were drained, it was immediately evident that *Spirogyra* had developed in those

Table VII. Experiment IVb. Effect of mixed stocking of *Cyprinus* and *Tilapia* on the yield.

rface of ponds (m^2)	Number *Cyprinus* stocked	Total weight *Cyprinus* (g.)	Number *Tilapia* stocked	Total weight *Tilapia* (g.)	Total yield *Cyprinus* in 1 month (g.)	Total yield *Tilapia* in 1 month (g.)
66	360	835	—	—	160	—
66	360	825	75	160	65	420
66	360	820	150	300	125	870

ked with carp and not in those with the ed stocking of carp and *Tilapia*. The dif- nce between the overgrown bamboo screens he carp ponds and the clean bamboo's in the s with mixed stocking, was striking.

It will be seen in Table VII, where results his experiment are shown, that the yield of carp is greatly reduced by the introduction of the *Tilapia*, although the total yield of both species combined is larger than that of carp alone. No correlation between the development of plankton and the introduction of *Tilapia* could be observed (Table VIII).

Table VIII. Experiment IVb. Effect of additional stocking with *Tilapia* on the biota of ponds stocked with *Cyprinus*.

Biota \ Number of *Tilapia*	0	75	150
hytoplankton, Number/l.	32,175	23,500	39,650
irogyra	—	++	++
otifera, Number/l.	525	100	—
rustacea, Number/l.	775	300	900
ligochaeta in bottom of pond, Number/24 ml.	2	4	3
hironomidae on bottom of pond, Number/24 ml.	4	4	6
iatomeae in bottom of pond, Number/24 ml.	2,070,000	1,036,000	1,705,000

It is evident from the results of the mination of the gut of the carp (Table IX) that he ponds with mixed stocking, the food of the consisted mainly of Chironomidae and stacea. In the controls a large quantity of *ogyra* had been eaten. Apparently the al food organisms of the crap, Chironomidae and Crustacea, were scarce in these heavily stocked ponds receiving no manure, and the carp was forced to use *Spirogyra* to a large extent. Therefore the *Tilapia* acted as a competitor for food with the carp in this case.

The gut of *Tilapia* contained vegetable food only, except for some Ostracoda, animals

always closely associated with the aquatic vegetation. Apparently the food had been collected, both from the bottom and from the open water.

As the possibility still existed that *Tilapia* might increase the yield of carp in manured ponds, experiment IVc was carried out, in the same ponds with daily doses of *Tithonia* in the bamboo screens and a mixed stocking of carp and *Tilapia*. Equal numbers of both species of fish were used and *Tithonia* was given in varying amounts as shown in Table X.

It can be inferred from the results of this experiment that the addition of *Tilapia* to the Common carp increased the effect of manuring with *Tithonia* (compare Experiment IVa), as witnessed by an increase in the yield of carp. The increase per kg. of *Tithonia* is higher in the ponds given a smaller dose of manure.

Table IX. Experiment IVb. Gut conten *Cyprinus* from ponds with various addit stocking of *Tilapia*.

Volume of food organisms, expressed percentage of the total gut contents of four

Number of *Tilapia*. / Biota	0	75
Chironomidae	31.6	48.2
Other insects	27.6	15.2
Oligochaeta	0.0	0.2
Snails	—	8.9
Crustacea	11.6	27.7
Thread algae	29.6	—
Gut contents of *Tilapia*.		
Euglena sanguines	+	
Blue-green algae	++	
Protococcales	+	
Diatomeae	++	
Detritus	+	
Thread algae	+	
Ostracoda	+	

Table X. Experiment IVc. Effect of manuring with *Tithonia* on the yield of ponds sto with *Cyprinus* and *Tilapia*.

Surface of ponds in m²		66	66	
Number *Cyprinus* stocked		330	330	3
Total weight *Cyprinus* stocked in grams		420	410	4
Number of *Tilapia* stocked		45	45	
Total weigth *Tilapia* stocked in grams		165	165	1
Total amount of manure given in kg.		0	225	
Total yield in one month in grams	*Cyprinus*	230	580	
	Tilapia	85	465	
Increase obtained from manure in grams	*Cyprinus*	—	350	
	Tilapia	—	380	
Increase obtained per kg. *Tithonia* in grams	*Cyprinus*	—	155	
	Tilapia	—	169	

le XI. Experiment IVc. Effect of manuring with various amounts of *Tithonia* on the biota of ponds, stocked with *Cyprinus* and *Tilapia*.

Biota \ Amount of *Tithonia*	0	22.5	45
ytoplankton, Number/l.	50,875	58,750	67,525
rogyra	—	++	++
tifera, Number/l.	175	200	75
ustaceae, Number/l.	525	3,100	1,675
igochaetae in bottom of pond, Number/24 ml.	5	4	1
ironomidae in bottom of pond, Number/24 ml.	3	4	3
igochaetae in *Tithonia*, Number/24 ml.	—	16	219
ironomidae in *Tithonia*, Number/24 ml.	—	20	2

It follows from the data given in Table hat, as was the case in Experiment IVa, the *nia* decomposing in the inflowing water d as a selective environment encouraging levelopment of Oligochaetae *Spirogyra* was d in the manured ponds, but not in quantities as high as those encountered in Experiment IVa. A marked increase in phytoplankton was observed in the manured ponds, followed later on by an increase in Crustacea. In Experiment IVa no such effect was observed.

le XII. Experiment IVc. Gut contents of *rinus* from ponds with constant additional cking of *Tilapia* and manured with various amounts of *Tithonia*.

nes of food organisms, expressed as percentage the total volume of gut contents of four fish.

ota \ Amount of *Tithonia* in kg.	0.0	22.5	45.0
Chironomidae	58.7	50.4	56.3
Other insects	7.2	5.7	4.9
Oligochaeta	2.5	6.0	1.0
Snails	24.4	8.8	7.0
Crustacea	9.0	24.3	25.9
Thread-algae	0.5	6.5	4.9
Mud	+	+	++
Decayed plants	+++	++	++
Euglena	—	M	—
Thread algae	+	M	M
Blue green algae	M	+	+

Note: M = Mass occurrence.

It will be seen in Table XII, that Chironomidae were ingested in about equal volumes in manured and numanured ponds, but that, by manuring, the volume percentages for Crustacea and *Spirogyra* increased.

In one case a very large number of Oligochaeta was found in the gut of a carp from a manured pond. Perhaps this fish had ventured inside the bamboo screen. As in Experiment IVa, the guts of *Tilapia* were filled with vegetable food only and often the organisms encountered were those not easily digested by the zooplankton *e.g.* cysts of *Euglena*, and *Spirogyra*, and always those organisms most frequent in the pond, taken without much selection. So, in this case, *Tilapia* prevents the accumulation of vegetable matter, thus liberating minerals and stimulating further development of phyto-and zooplankton. The stimulating effect of *Tithonia* and *Tilapia* combined might be depicted as follows. Animals feeding directly on the decomposing *Tithonia*, such as Oligochaeta, will become direct food for the carp, and the minerals liberated by the decomposing plant tissue will be taken up by *Spirogyra* and other algae. When these algae are eaten by the *Tilapia*, the minerals become available once more and will give rise to a development of phyto-

plankton, the latter group again serving as food for the carp.

In Experiment IVd the effect of different numbers of *Tilapia* on carp growing in ponds manured with equal amounts of *Tithonia* investigated. Number of fish stocked and are presented in Table XIII.

Table XIII. Experiment IVd. Effect of additional stocking of *Tilapia* on the yield of ponds stocked with *Cyprinus* and manured with *Tithonia*, decomposing in the inflowing water.

Surface of ponds in m^2	66	66	66
Number of *Cyprinus* stocked	240	240	240
Total weight of *Cyprinus* stocked in grams	360	360	360
Number of *Tilapia* stocked	—	6	12
Total weight of *Tilapia* stocked in grams	—	110	220
Total amount of *Tithonia* given in kg.	22.5	22.5	22.5
Total yield of *Cyprinus* in one month in grams	230	310	460
Total yield of *Tilapia* in one month in grams	—	190	340
Increase in yield in grams of *Cypriuus* caused by additional stocking	—	80	230

It will be observed that the yield of carp showed a considerable increase as a result of the addition of *Tilapia*. It may be inferred from the data given in Tables XIV and XV that additional stocking of *Tilapia* acts favourably on phytoplankton development. Although an accumulation of Oligochaeta in the decaying *Tithonia* could be demonstrated in one pond only, the fact that the percentage of Oligochaeta ingested by the carp was much higher in all ponds than in all previous experiments, might indicate that these worms develop in all cases under these circumstances, but are only incidentally captured with our simple methods owing to their u distribution in the decaying *Tithonia* in lo patches. The carp alone feeding in por seen to ingest more Crustacea and those f in association with *Tilapia*, more Chirono Probably the amount of Crustacea av almost the same in the three sets of ments, was insufficient for the needs biggercarp — 4.4 instead of 2.9 g. a weight in the ponds with additional st and the large masses of *Spirogyra* in the without *Tilapia* might have inhibite feeding on bottom animals.

Table XIV. Experiment IVd. Effect of additional stocking of *Tilapia* on the biota of pond stocked with *Cyprinus* and manured with decomposing *Tithonia* in the inflowing water.

Number of *Tilapia*	0	6	12
Phytoplankton, Number/l.	202,900	763,100	879,0
Spirogyra	+++	—	
Rotifer, Number/l.	125	—	
Crustaceae, Number/l	400	500	5
Oligochata on bottom of pond, Number/24 ml.	1	1	
Chironomidae on bottom of pond, Number/24 ml.	3	6	
Oligochaeta in decaying *Tithonia*, Number/24 ml.	3	74	
Chironomidae in decaying *Tithonia*, Number/24 ml.	7	9	
Diatomeae on bottom of pond, Number/24 ml.	not investigated		

In 1952, some experimants on mixed stoc- of *Cyprinus* and *Tilapia* were carried out aas and Hofstede *(loc cit)* in other ponds e same hatchery. These experiments differ ours in the following respects:

1) The ponds were drained every week, ie normal development of food organisms interrupted.

2) Equal numbers of both fish were stoc-

As in our Experiment IV no manure or r was given, and in both experiments the ional stocking of *Tilapia* interfered with rowth of the carp.

However, it follows from our later experi- s that in manured ponds growth of carp be increased by an additional stocking of *ia* at appropriate rates.

In order to facilitate comparison of the ts of the above mentioned experiments, nally carried out in ponds of different size with fish of diflerent size, and to various ing rates, a summary of results is given able XVI where stocking rates have been ssed in numbers/ha. and yields in kg./ha./ h.

le XV. Experiment IVd. Gut contents of *prinus* from ponds, manured with equal ounts of *Tithonia* and with different additional stockings of *Tilapia*.

mes of food organisms expressed in centage of total volume of the gut contents of four fish.

Biota \ Number of *Tilapia*	0	6	12
onomidae	33.5	58.0	59.5
er insects	12.5	20.0	8.5
ochaeta	12.0	6.0	22.0
stacea	38.0	10.0	8.5
nt tissue and thread algae	4.0	7.0	0.5
ains of fish	+	—	—
ils	+	—	—

It is emphasized that the figures in this Table were obtained from the original ones by multiplication with fairly large factors and that experiments will have to be carried out on a commercial scale, in order to determine the most economic way of using *Tithonia* and stocking the ponds with Common carp and *Tilapia*. The results described above will act as a guide in such experiments.

It will be seen from the Table XVI that, in our experiments, the best effect was obtained from *Tithonia* when fresh stalks with leaves were added to the inflowing water and the ponds were stocked with 35,000 carp/ha., of an average individual weight of 1.3 g., together with 1,800 male *Tilapia* of an average individual weight of 18.3 g.

SUMMARY

Experiments were carried out in order to investigate the influence of manuring with *Tithonia diversifolia* Gray, (Marygold) on the yield of ponds stocked with *Cyprinus crapio* L. alone and in combination with *Tilapia mossambica* P.

1) Fresh stalks with leaves thrown into concrete tanks, stocked with carp of 21 g. individual weight.

2) Fresh stalks with leaves thrown into ponds, stocked with fry, advanced fry and fingerlings in three monthly periods (Tables I and II).

3) Previously decomposed *Tithonia* given in concrete tanks, stocked with carp weighing 20 g. each (Tables III and IV).

4) *Tithonia* given in bamboo screens put into the pond at the inlet. Some of the ponds additionally stocked with male *Tilapia* at various rates (Tables V-XV).

It was concluded from data on the yield, the biota of the ponds and the gut contents of the fish, that maximal increase in yield is obtained by manuring in the inflowing water, in ponds stocked with fry of the Common carp together with large male *Tilapia*.

An explanation was sought in the direct influence of the large development of Oligochaeta among the decomposing vegetable matter and in the indirect effect of liberation of minerals caused by the decomposition. Algae, such as Spirogyra. encouraged by the organic

Table XVI. Summary of results.

Working method	Stocking rate carp/ha.	Average individual weight carp (g.)	Amount of manure kg./ha.	Stocking rate *Tilapia* No./ha.	Average individual weight *Tilapia* (g.)	Increase in yield caused by *Tithonia* per ha./kg./ month (g.)	Increase in yield per kg. *Tithonia* (g.)	Yield of *Tilapia* in kg./ha./ month
Fresh stalks and leaves directly thrown into the pond	8,300	21.00	16,600	—	—	24,900	1.5	
,,	100,000	0.15	1,500	—	—	12,750	8.5	
,,	100,000	0.15	3,000	—	—	27,900	9.0	
,,	50,000	2.70	1,500	—	—	7,950	5.3	
,,	50,000	2.70	3,000	—	—	18,900	6.3	
,,	25,000	5.60	1,500	—	—	20,250	13.5	
,,	25,000	2.60	3,000	—	—	18,300	6.1	
Tithonia previously decayed	8,300	14.00	16,600	—	—	13,280	0.8	
	8,300	24.30	33,200	—	—	9,960	0.3	
Tithonia given in inflowing water	80,000	1.40	3,400	—	—	14,960	4.4	
,,	80,000	1.40	6,800	—	—	24,480	3.6	
,,	50,000	1.30	3,400	6,800	3.6	52,920	15.5	25,600
,,	50,000	1.30	6,800	6,800	3.6	85,000	12.5	39,200
,,	36,300	1.30	3,400	900	18.3	26,860	7.9 *	15,900 * *
,,	36,300	1.30	3,400	1,800	18.3	59,440	16.6 *	38,600 * *

* Calculated by comparing Experiment IVd with IVa (*Tithonia* without *Tilapia*).

* * Calculated by comparing Experiment IVd with IVc (*Tilapia* without *Tithonia*).

ure not digested by zooplankton and of ed nutritional value for the carp, were n by the *Tilapia*.

Under certain conditions the number of onomid larvae in the ponds shows an ease because egg-laying adults are attracted he decomposing plants, as was described by r workers.

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EXPERIMENTS ON DIFFERENT STOCKINC RATES OF THE COMMON CARP*

(*Cyprinus Carpio* L.) IN NURSING PONDS

by

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ABSTRACT

A series of experiments on stocking rate was carried out in the hatchery of the aboratory for Inland Fisheries, Bogor, Indonesia.

The individual growth and the total yield at different stocking rates were determined. he relationship between food ingested, food. used for maintenance and food available for rowth could be calculated from the figures obtained.

Biota in the water and on the bottom of the pond as well as excrements were ıvestigated every eight days. At the end of the stocking period the contents of the ıtestines were investigated.

From a consideration of all results obtained it was concluded that at the optimal :ocking rate the minerals are most rapidly incorporated by the carp into the flesh of ıeir body; in this case they are no longer available for phytoplankton. So the total mount of organic matter formed is low, but the food is utilised in a most economic way. .t overstocking a large amount of minerals is circulating rapidly, a high amount of rganic matter is formed, but almost the entire amount is needed for maintenance. At ɔw stocking rates, the minerals are circulating slowly and part of the food formed is left neaten by the carp. However the amount needed for maintenance is low.

INTRODUCTION

Freshwater pond culture is carried out in nesia in densely populated districts. For this ɔn it is most important to obtain maximum ls from minimum areas. To accomplish this necessary that the amount of fish food avai- be converted into fish flesh in the most ıomic way. One of the principal factors in respect is the optimal stocking rate. More- attention should be given to the amount of ral food produced in the pond and ingested he carp during the period of growth and the ıence of various stocking rates on these fac-, regarding the pond as a closed ecosystem.

In Germany Walter (1931) carried out ıerous experiments on fish production in ds and Contag (1931) investigated the deve- ıent of food organisms at various stocking s.

At the Third International Inland Fishe- Training Centre at Bogor in 1955, the ent author presented an essay on the biolo- l interpretation of Walter's results.

This theory was summarised in a set of ɔhs (Fig. 1).

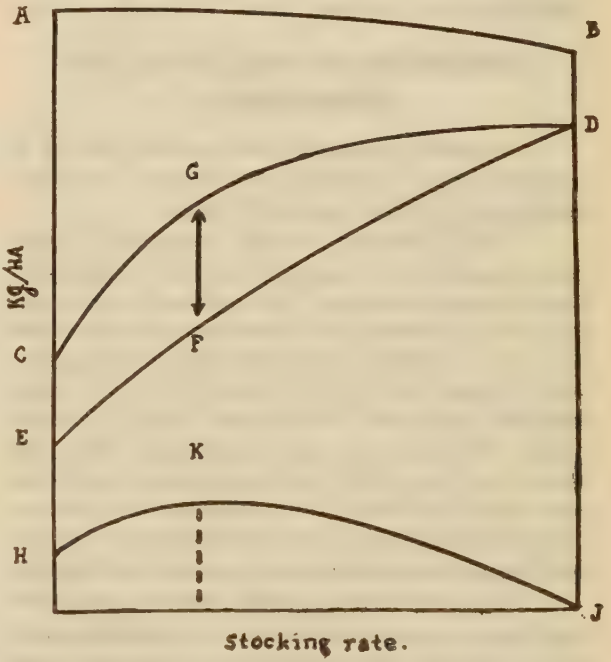

Fig. 1. Theoretical scheme of food and feeding of carp in a pond at increasing stocking rate.
AB = Total supply of food.
CD = Amount of food ingested.
ED = Amount of food needed for maintenance.
HJ = Amount of food available for growh.

*Compilation in English of the Reports of the Laboratory for Inland Fisheries, Bogor, Nos. 11, 12, 13, 14 by authoress.

It was supposed that actual growth would be proportional to the amount of food available.

In the present paper we shall describe an attempt to test this theory, especially under tropical conditions.

The investigations were carried out by a team, consisting of the following members of the staff of the Laboratory for Inland Fisheries, Bogor : Abdul Rachman, Suherman, Much. Machfud and N.R. Harahap, under the direction of the author.

Chironomidae from the mud and the gut contents of the carp were studied by K.F. Vaas.

The author is indebted to Hasanuddin Saanin, Director of the Laboratory, for being given the opportunity to carry out this work and for various valuable suggestions in the course of the experiments.

J.A. Schuurman, Bogor, kindly reviewed the English of the text.

DESCRIPTION OF THE PONDS AND EXPERIMENTS

Four experiments were carried out in 12 concrete tanks with a surface area of 18 square metres each, and a depth of 30 cm.

The inflowing water contained a good deal of particulate organic matter, originating from domestic sewage. The sediment amounted to 0.5 cc./l. The sides of the sewer from which the water entered the tanks were overgrown with filamentous algae, forming a slimy mass together with mud. In the mass many Chironomidae, Oligochaetae etc. were found. After the tanks had been filled, no water was let out and only the losses caused by evaporation were replaced. So the tanks were almost closed systems, containing equal amounts of organic substance.

The particulate organic matter settled on the bottom, and some leaves from neighbouring trees fell into the tanks in the course of the experiment and a layer of approximately 2 centimetres of mud was always formed on the bottom. In normal ponds the surface layer of the mud is the most important site of physico-chemical interrelations. It therefore seems justified to compare our tanks with ordinary tanks.

The tanks were stocked with various numbers of fry and drained and cropped after one month.

Owing to the small size of the t was necessary to stock with advanced f optimal stocking rate for bigger carp probably have been less than 1 carp pe

After 1 month the following det tions were carried out :

1) Total number and weight of th

2) Individual weight, total leng standard length of approximately 10% fish.

3) Net plankton, strained from litre of water, taken from 10 differen immediately before draining the tank.

4) Nannoplankton from 1 litre o passing the plankton net during the st of the net sample. The numbers of org in both samples were computed on th of counts of twice 0.02 cc. of the samp

5) In 8 different places mud s were taken with a glass tube with an c width of 1 square cm. The whole mud was studied under the binocular mic and conspicuous organisms, such as C midae, Oligochaetae insect larvae an were picked out and identified as far sible. Afterwards the mud was dilute water to a volume of 100 cc. and micros ly studied in the same way as the p samples. The number of algae on the was only counted at the time the tank drained. Large differences between th were observed, and no correlation w stocking rate could be found. The number for all tanks combined amou 6.5 million/dm^2 of mud.

6) The gut contents of 2 car studied.

7) Samples of the contents of t part of the guts of about 10% of the li were collected by gently pressing the of the vent. The fish treated in this w released in their original tanks. The collected were studied in the same way gut contents. This determination was out in the fourth experiment only.

Four experiments were run. In t three experiments, 4 different stockin were used with 3 parallels; in the fourth ment, 6 different stocking rates with 2 lels. The numbers used were the follo

Experiment	I	30	45	50	75	
„	II	20	40	60	80	
„	III	3	10	17	24	
„	IV	10	15	20	35	65	110 —

In Experiments I, II and III fry of an e weight of 1.5 g. were used, in Experi- V the average weight amounted to 1 g. xternal circumstances in Experiments I, III were similar, but for minor differen- climatic conditions. Therefore the were combined. As losses were heavy king rate 110, the average between the r stocked and that cropped was used calculations. This was about 100.

ATION BETWEEN TOTAL YIELD AND INDIVIDUAL GROWTH

The average individual growth of the nd the total yield per tank are shown in I and II. The discrepancies between the ls are caused by incidental differences ility between the tanks and by climatic ons. Inevitable losses of fish during the periods also cause difference in yield individual growth. If the loss occurs in ginning of the period, the individual at the time of draining will be too high, loss takes place towards the end of the and if it involves the bigger carp, the e weight may become too low. The figu- tained were plotted in Fig. 2 and 3, in individual growth is represented by dots. gh these dots the best fitting curve was by eye.

Multiplication of the various values, as om this line, by the relevant stocking provided theoretical values for the total These theoretical values are indicated in ures by crosses. The actual total yield ked by circles.

In agreement with Walter's results the rise rapidly up to a certain optimum and slowly afterwards.

The following considerations enable us ulate the amount of maintenance food ssed in arbitrary units U), the amount l used for growth (expressed in the same nd, by adding up these values the amount l ingested by the entire population.

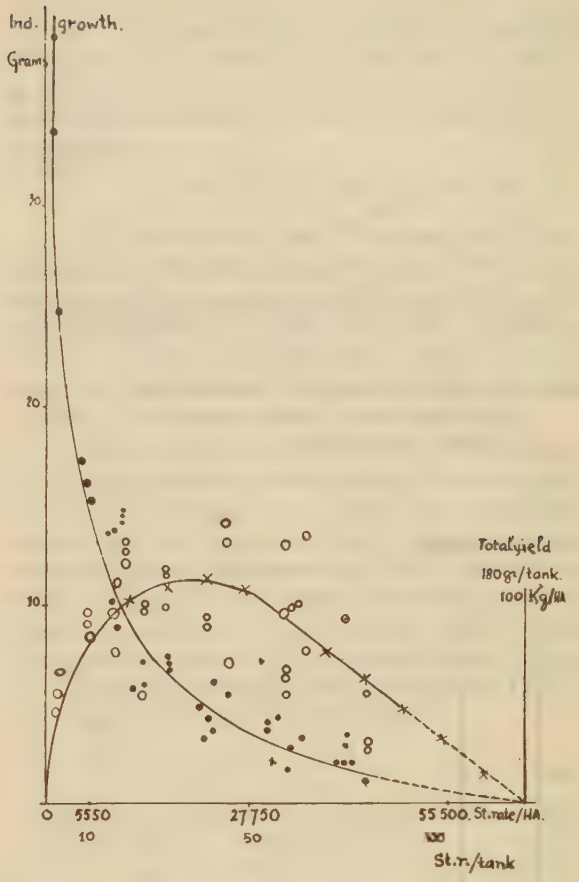

Fig. 2. Growth of carp at increasing stocking rates. Experiments. I, II and III
.–.–. Individual growth in grams.
x–x–x Total yield, calculated from individual growth.
o o o Total yield, actual values.
– – – Hypothetical part of the curve.

It is a well known fact in animal physiology that the amount of maintenance food needed by an animal is proportional to the surface of the body, which value again, is proportional to the ratio between weight and length.

It can be inferred from Fig. 2 that, in the tanks used here, a total yield of zero will be reached at a stocking rate of 120 carp per tank (equal to 66,660/ha.) when fry of 1.5 g. is used. The dotted line in the figure represents the hypothetical values at higher stocking rates than those used. However, such values are seldom reached in actual practice. At higher

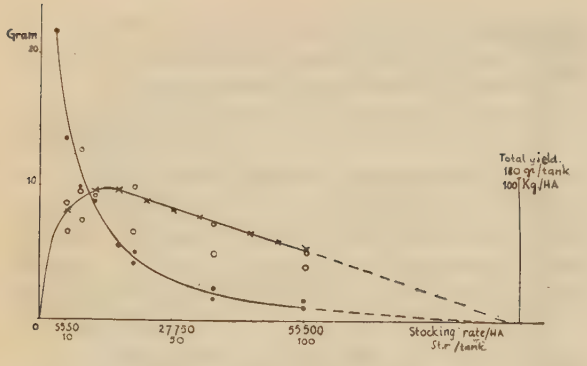

Fig. 3. Growth of carp at increasing stocking rates. Experiment IV. Legend as in Fig. 2.

stocking rates heavy losses will occur a rate is automatically reduced, enabling t maining carp to grow on. It is even p that under such conditions some of the carp are eaten by the remaining ones tomarov and Hrabé, 1943). In aquaria the saw carp nibbling at the bodies of carp milar size lying on the bottom.

With carp of 1 g. a total yield o will be reached at a rate of 175 fish pe

As it was necessary to obtain a f expressing the relationship between st length *(L)* and weight *(W)*, a number o were weighed and measured every 8 d Experiment IV. Logarithms of the figures

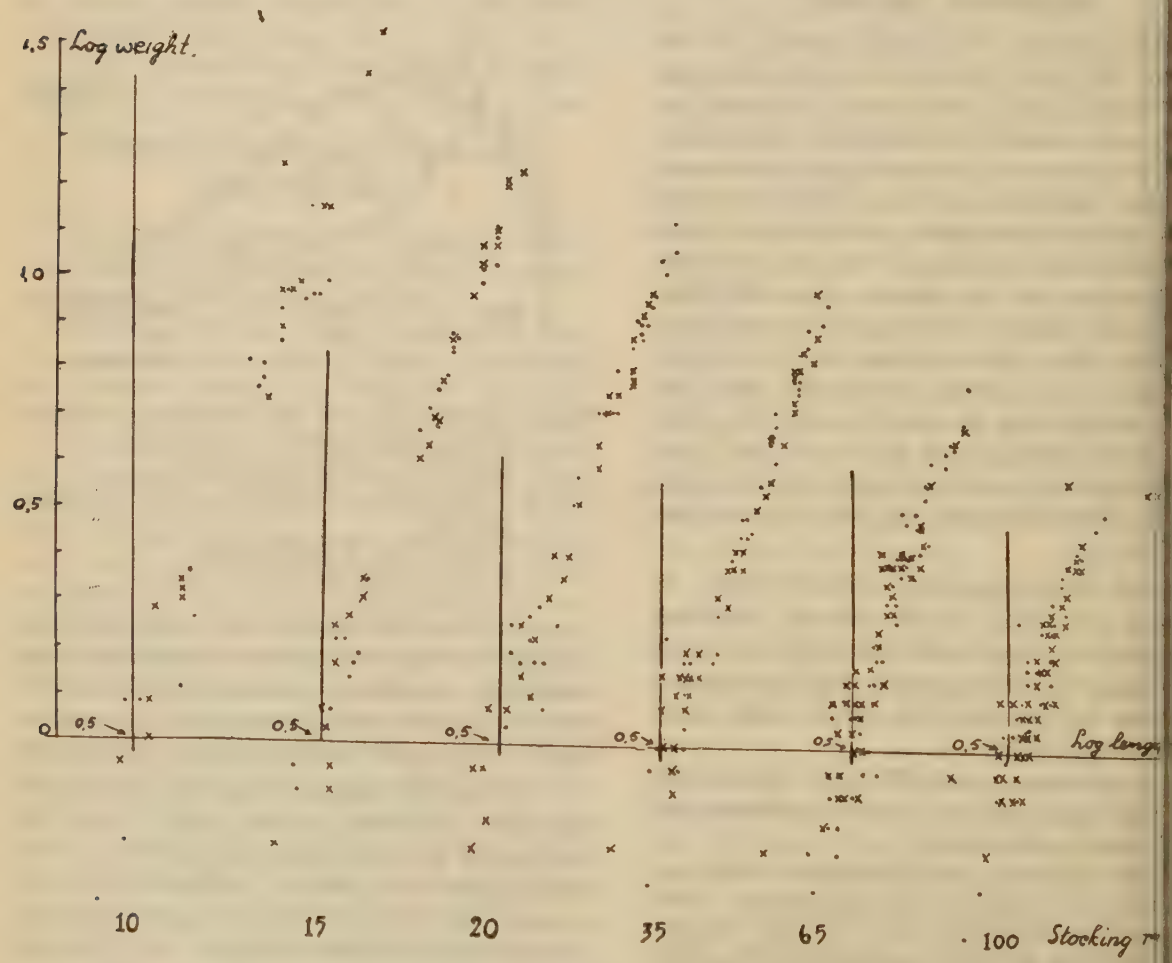

Fig. 4. Ratio between logarithms of weight and length at different stocking rates, resulting formula $\log W = 3 \log L - 1.5$.

lotted in Fig. 4. For each stocking rate gures obtained in the first parallel are ted by dots, and those found in the second el by crosses.

As will be seen in the figures the relaiip between the two values can be represen- straight lines, representing the formula :

$\log W = 310$ g. $L - 1.5$ (or: $W = 0.032\ L^3$)

If the total weight and the number of a n stocking of carp are known, the average n can be calculated with this formula.

However, what matters here is the ge weight of the carp during the whole n of the growing period. In Experiments nd III the initial weight and the ultimate nt only were determined. The average of two values need not represent the actual ge during the entire period. For this n weights found at various intervals during iment IV were plotted and growth curves obtained at different stocking rates, by the f these values (Fig. 5).

By comparing the average values at is points on these curves with the averages een initial and ultimate weight, we obtained rection key, to be applied to the different idual weights found in Experiments I, II II (Table III). It will be observed that this ction key need only be applied at low stockates.

As was pointed out earlier, the amount of enance food needed by one fish is proporl to the quotient of weight and length. In ase this value amounted to 0.31 for carp gram. As a unity of food *(U)* we wish to duce the amount of maintenance food ed during 1 month by 1 carp. The amount intenance food *(A)* needed during 1 month population of carp of known average weight ength as expressed in U, may be calculated the aid of the formula:

$$A = N \frac{q}{0.31}$$

hich N = stocking rate and q = quotient of nt and length.

It appears from Fig. 3 that no growth red at a stocking rate of 175 carp of 1 gram. equently, in that case 175 U of food were ted and totally needed for maintenance. rate of 150 carp per tank, the individual growth amounted to 0.2 gram, and the average weight of the carp during the entire period was 1.1 gram. The quotient of weight and length in this case being 0.34, the amount of maintenance food needed by the whole population of the tanks was :

$$150\ \frac{0.34}{0.31} = 168\ U$$

If it is assumed that the amount of food ingested by 150 carp equals that ingested by 175 carp, which assumption seems justified at such a high stocking rate, 175-168 = 7 U are left for growth. The total yield being 150 x 0.2 = 30 gram, we find that 1 U of food yields 4.3 gram of carp.

We already stated before that the amount of maintenance food needed may be calculated for every stocking rate. Since the total yield divided by 4.3 represents the amount of food used for growth, expressed in U, the total amount of food ingested is obtained by adding the two figures mentioned. Calculations along these lines were carried out for Experiments I, II and III combined as well as for Experiments IV and are shown in Table IV and Fig. 6.

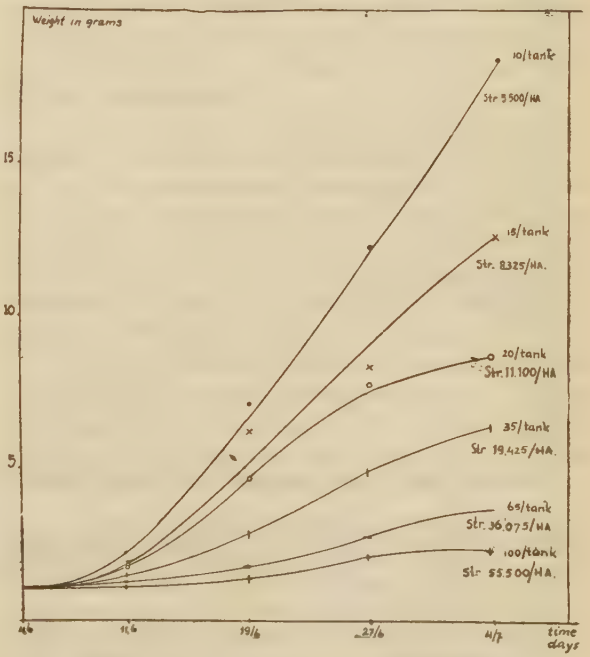

Fig. 5. Growth curves at various stockings with fish 1 gram each.

The general conclusions to be drawn from these calculations are the following:

1) Individual growth declines as the stocking rate increases. This decline is rapid at low stocking rates and slow at high ones.
2) The total yield rises rapidly at increasing stocking rates, up to a certain optimum. Beyond that optimum a very slow decline takes place.
3) At increasing stocking rates the amount of food ingested rises rapidly at first and slowly afterwards. At stocking rates of more than 60 carp of 1.5 gram, this amount hardly increases at all.

These conclusions are based on the assumption that individual growth is primarily determined by the amount of food available for each carp.

In pond-culture practice it is usually assumed that food production during the whole period of growth in the pond is independent of the stocking rate.

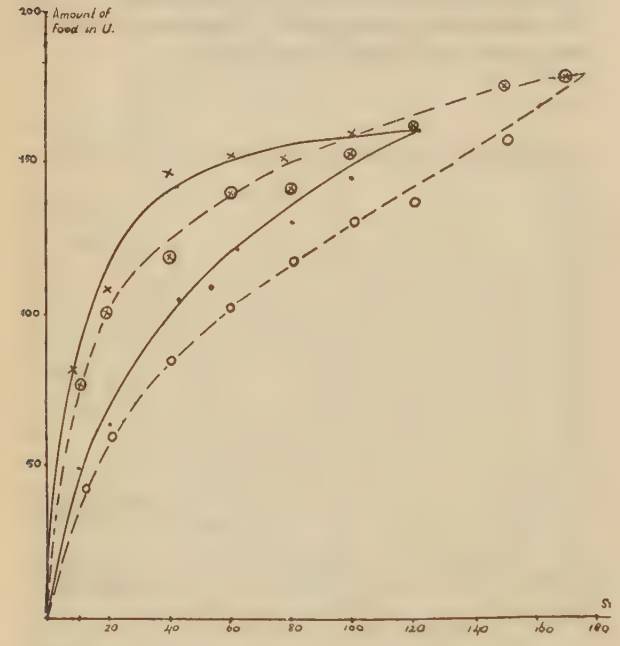

Fig. 6. Total amount of food ingested and maintenance food calculated at increasing stocking rates.

.—.—. Maintenance food
×—×—× Total amount of food ingested } Stocking with fry of 1.5 gram.

o—o—o Maintenance food
⊗—⊗—⊗ Food ingested } Stocking with fry of 1 gram.

This assumption is the basis of the calculation of the stocking rate. If this true in our case, and food production amo to 175 *U* at all stocking rates, the amount available for each carp could be calculated amount of food needed for maintena various stocking rates may be calculate the values given in Table IV. By subtr the amount of food available for growth i determined (see Table V), and by multipl with 4.3 the expected growth in grams is By comparing these figures with growth a measured, large discrepancies are found stocking rates. So it must be concluded low stocking rates, either part of the food unused, or food production is less than 17

Which of these two conclusions is c may be decided on the basis of limnc investigations. It is also possible that b true. However, the large differences be the amount of food ingested at stocking r and 20 seem to indicate that the first hyp is the more probable one. The graphs sh individual growth during the whole (Fig. 4) prove that growth is slow in th week, accelerating during the second wee that the lower the stocking rate the lon increase in growth continues.

LIMNOLOGICAL INVESTIGATION

A) Ecology of the tank.

In Table VI the results of plankton are given in a simplified form, in whic genera of special importance are mea separately, while the others are combin taxonomic groups.

The most important organisms fo the mud are shown in Table VII Spyrogy encountered often, but not in large qua *Lebistes reticulatus* P. and frog larvae always present in the tanks.

The gut contents of all animals in the ecosystem of the tank were briefly and the results are given in Table VIII

ble VIII. Gut contents of water biota in the tanks.

toria	Phytoplankton, Protozoa,
tacea	Phytoplankton
nomidae	detritus, algae from the mud.
chaetae	do do
merid larvae	do do
ara	do do
nia	do do
larvae	Phytoplankton, notably Euglena from the surface Rotatoria.
stes	Chironomidae, Crustaceae, Rotatoria, Oligochaetae detritus.
ns carpio	Chironomidae, Crustaceae, Oligochaetae, Insect larvae. Less Frequent: Spirogyra, snails.

These organisms may be classified in the wing ecological groups, on the basis of their onships with the carp and of the way in h they affect the circulation of free miner- issolved in the water.

Phytoplankton. Forming organic matter rapidly. Using dissolved minerals, but equally rapidly eaten by various animals, for which reason minerals are quickly liberated.

Bottom algae. Using free minerals. Forming organic matter. Eaten by Chironomidae, some other insect larvae, Oligochaetae and snails.

Spirogyra. Forming organic matter and using free minerals rapidly. Eaten by very few animals only, therefore often "side tracking" minerals by incorporating them for a long time.

Protozoa. Living on phytoplankton and on other Protozoa. Eaten by Rotatoria.

Rotatoria. Living on phytoplankton. Eaten by Lebistes to a small extent.

Crustaceae. Living on phytoplankton. Principal food of the carp. Eaten by Lebistes.

Insect larvae (mainly Chironomidae). Living on detritus and mud algae. Not propagating in the tank, only growing, and leaving the ecosystem when adult. Eaten by carp and Lebistes.

Oligochaetae. Living on detritus and algae. Propagating in the tank. Eaten by carp and Lebistes. Not significant as food for the carp, owing to low numbers and small volume.

9) **Snails.** Living on mud with algae. Small ones eaten by large carp. They accumulate in the tank, "side tracking" minerals.

10) **Frog larvae.** Living on phytoplankton. Not eaten by any other animal present. "Side tracking" minerals, but not a real food competitor of the carp. The food stored inside the body leaves the tank at the time the metamorphosis is accomplished.

11) **Lebistes.** Living on Chironomidae, Crustaceae, Oligochaetae and Rotatoria. Not eaten by any other animals present. Propagating very rapidly. Serious food competitor of the carp. Storing minerals in the body, which are only liberated after complete mineralisation of the dead body in the tank.

12) **Carp.** Living on Chironomidae, Crustaceae, other aquatic insects and their larvae, to a certain extent also on snails and Spirogyra.

INVESTIGATION OF THE PLANKTON AND THE BIOTA OF THE MUD

In Experiment IV, samples of the plankton and the mud were collected every 8 days. The number for each genus was counted and finally the volumes of these organisms were calculated by multiplication with certain factors, previously established.

Such calculations were made for: Phytoplankton, Rotatoria and Crustaceae.

The results are presented in Fig. 7, the solid line representing the first of the two parallels, and the broken line the second one. Protozoa are not represented, because they were abundant during the first 8 days only, their numbers being negligible afterwards.

Although oscillations in the numbers of plankters were encountered, as was the case in the course of investigations by other workers (Wirzhubsky 1953, Yun An Tan 1954) it is nevertheless possible to draw certain conclusions.

In all tanks the inflowing water introduced hardly any plankton, after 8 days a small amount only had been formed. After 16 days phytoplankton was abundant. In most cases the lines representing the numbers of adult Crustaceae and Rotatoria followed those of the phytoplankton. The number of nauplii was seen to fluctuate more than that of all other biota.

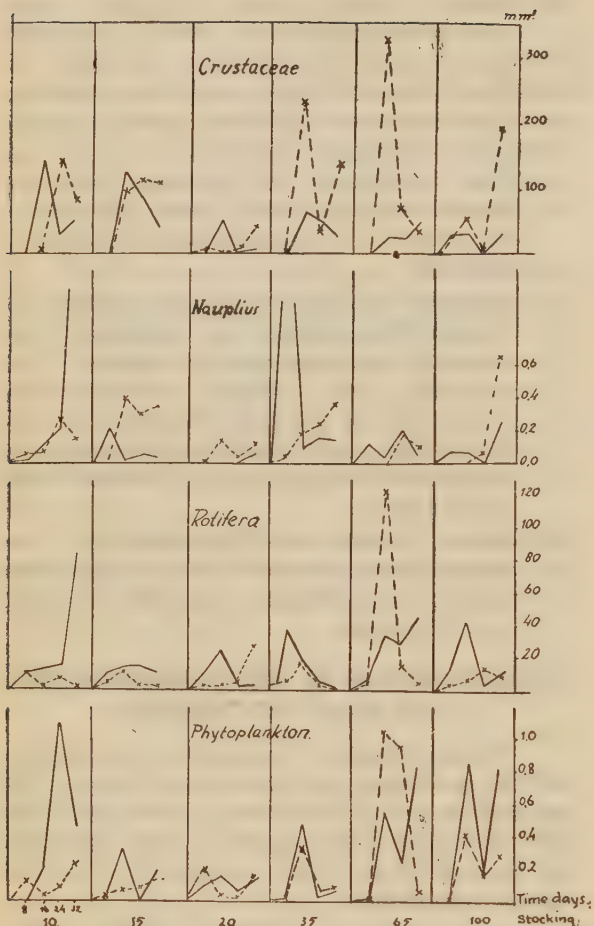

Fig. 7. Volumes of the most important groups in the plankton during the period of growth at different stocking rates.

By comparing the results at different stocking rates we see that, at the optimal rate of 20 carp per tank, both phytoplankto zooplankton reach a minimum. This m explained as follows: The minerals in the are rapidly incorporated into the body carp, rendering them unavailable for the tion of phytoplankton. In heavily stocked a good deal of zooplankton is eaten but all food is used for maintenance of the Only a small fraction of the minerals is porated by the carp and a large fract excreted and becomes once more availa the phytoplankton. Minerals circulate r and the amount of organic material form the tanks is high, as is demonstrated b large amounts of plankton. Rotatoria are cially abundant in this instance because organisms are hardly ever eaten by othe in the tank.

In slightly stocked tanks the amo maintenance food needed is low. The amount of food ingested by the small n of carp is rather low too, so that the a life span of the Crustaceae must be rathe But, as the circulation of minerals is so the formation of phytoplankton must b too. The incorporation of minerals in body of the carp will be less than in th of intermediate stocking at the optimal Therefore more minerals will remain av for phytoplankton until the end of the g period.

The total amount of organic matt med in the tank by photosynthesis w minimal at intermediate stocking rates, mediate at low stocking rates and maxi high stocking rates.

The consideration set forth above by summarized as follows (Table IX).

Table IX. Relation between stocking rate, circulation of minerals and production organic matter in a fish pond.

	Stocking rats	
	Low	Intermediate
Maintenance food	Low	Intermediate
Minerals incorporated by the fish	Intermediate	Much
Circulation of minerals	Slow	Intermediate
Amount of minerals circulating	Intermediate	Small
Organic matter formed	Intermediate	Little

Among the organisms living in the mud, chaetae and, notably, Chironomidae are the most important food for the carp.

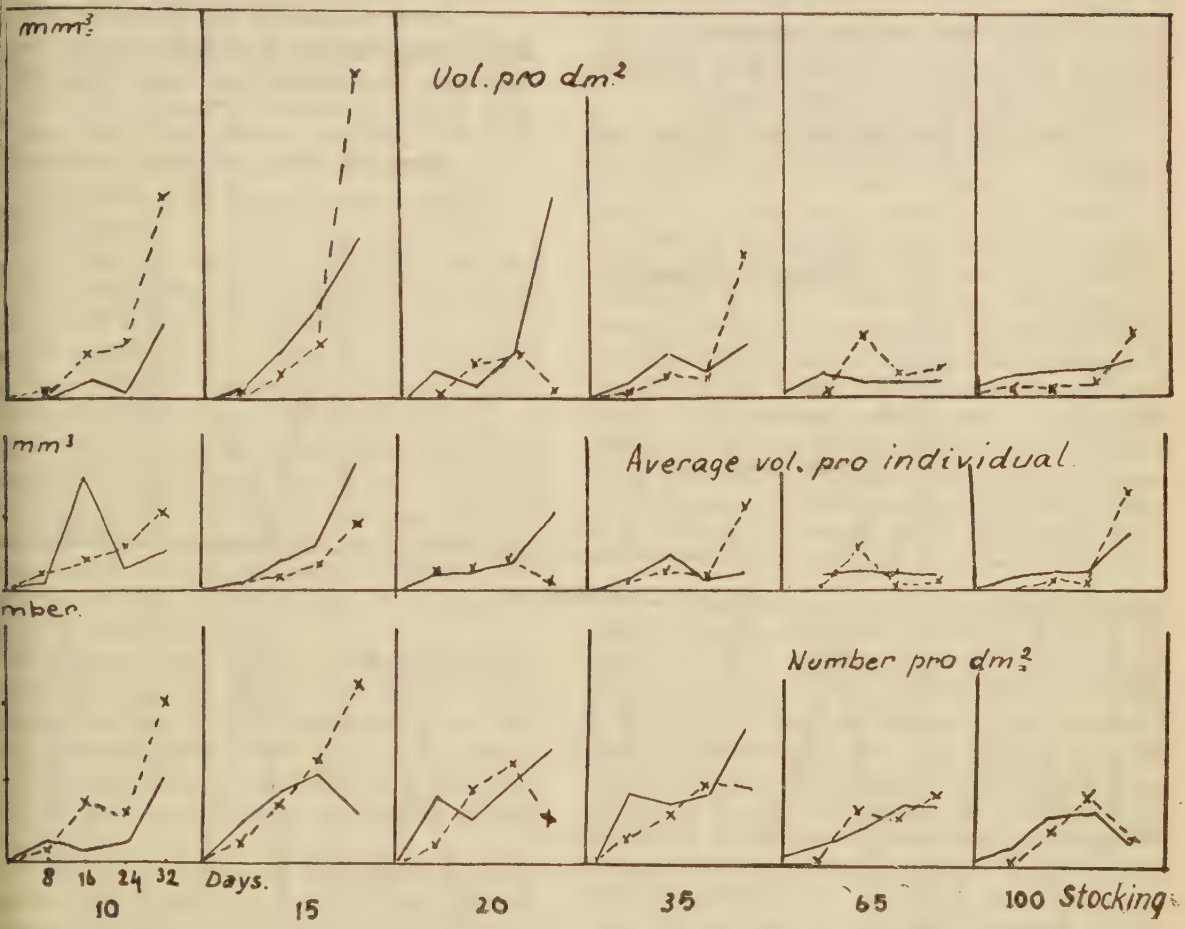

Fig. 8. Numbers and volumes of Chironomides collected from the mud during the period of growth at different stocking rates.

The numbers found in our experiments hown in Fig. 8. The numbers will be seen se during the course of the growth period, pt in some heavily stocked tanks. The quantity proves to be high in the tanks a low stocking rate. As the size of the nomidae seems to vary, all larvae were ured and their volume calculated. The ts are given in Fig. 8. It will be seen that number, as well as the average volume of nomidae is higher in the slightly stocked s. This is in accordance with Contag's ngs.

No connection can be observed between number of Chironomid larvae and the phytoplankton. These larvae obviously do not propagate in the tanks and a heavy stock of them is always present in the sewers. As the metamorphosis there remains undisturbed, the number of ovulating midges is permanently high and egglaying females do not have any reason to prefer any special tank. It seems warranted to assume that the number of eggs deposited in each tank is the same.

The number of algae found in the mud is always very high and no effect of the different stocking rates was observed. For this reason the food supply will not be a limiting factor for Chironomid larvae. Therefore the

number and volume of Chironomidae will almost exclusively depend on the amount consumed by the carp. In heavily stocked tanks these larvae will be eaten almost immediately after hatching and only few of them will have the opportunity to grow to a large size.

Therefore, both number and volume, will be low.

EXAMINATION OF THE GUT CONTE AND FAECES OF THE CARP

After the tanks had been drained end of Experiments II and III, the gut co of 2 carp from each tank were examin K.F. Vaas.

From our point of view, the most

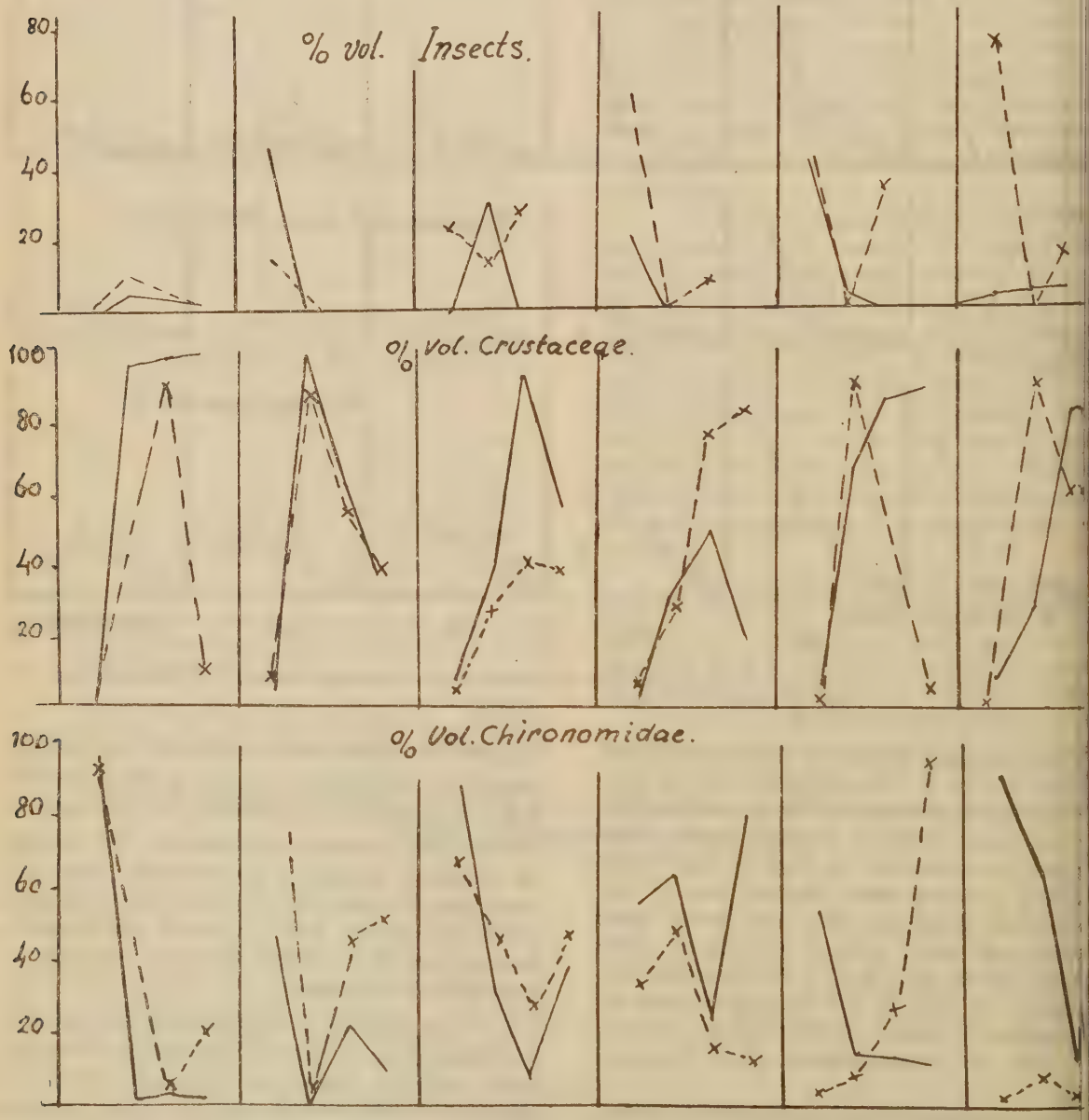

Fig. 9. Organisms found in the faeces, in percentages of the total volume.

; figures are those representing the percen- for the volume occupied by various orga- in the guts. These figures are contained ibles X and XI.

It will be observed that the percentage ustaceae remains constant for all four ing rates, whereas the percentage of Chi- nidae declines as the stocking rate de- es.

The amount of plant tissue is higher at igher rates.

Only at the very low rate of 3 carp per in Experiment III (Table 9), was a high ntage of plant tissue found.

As stated in other papers by Vaas (in Proceedings) big carp often eat plant even when other food is available.

However, it appears that the less the other is available the more plant tissue is eaten.

Only small differences observed in the ntage of Crustaceae may be explained by act, mentioned in an earlier chapter, that ge amount of zooplankton is formed in eavily stocked tanks.

However, the number of Chironomidae ible is primarily determined by the num- aten by the carp. Consequently, at the of the experiment their number is low at stocking rates. Then the carp turns to food such as plant tissue including thread

The best insight into the feeding habits carp during the course of an entire period rowth cannot be obtained from samples at the end only, but from samples taken tervals. As it was impossible to reduce the ber of fish during the period, it was deci- to examine their faeces, simultaneously the biota of the tank. The number of carp which faeces were collected bore the ving relation to the stocking rate :

Stocking rate :	10	15	20	35	65	110
Number of carp :	4	5	6	8	10	12

The amount of faeces not being constant, volumes of identifiable organisms were ssed in percentages of the total volume. results are presented in Fig. 9.

At the end of the first period of 8 days is found that, in most tanks, mainly Chi- nidae had been ingested, at the end of the second period mainly Crustaceae, and during the third and fourth poriod of 8 days both groups in varying ratios.

Comparison of these results with the data showing availability of Crustaceae in the tanks at the same time, shows a positive correlation.

At the end of the first period of 8 days, the amount of Chironomid larvae in the guts was high for all tanks, although the amount available in the tanks was low. However, in the second period the amount of the larvae in the mud increased, but the amount in the guts decreased rapidly. During the third and the fourth period the percentages of these larvae in the guts and in the mud appear to correspond. In conformity with conclusions drawn from limnological observations, the number of Crustaceae was found to be determined by the number of phytoplankters in contrast to the situation found in the case of Chironomidae, for which ingestion by the carp proved to be the main regulating factor.

Summarizing we obtain the following picture concerning the choice of food by the carp. In the early period of growth, when plankton has not yet developed, Chironomidae are eaten as soon as hatched. Their number is therefore reduced by the carp, but, by the time zooplankton has formed, the stress on the midge larvae is somewhat reduced, as Crustaceae are ingested in increasing numbers, and the Chironomidae can grow out. Later on, as the carp have increased in size, the development of the zooplankton is too slow to supply the increasing amount of food needed by the fish and they again turn to Chironomidae. Particularly in heavily stocked ponds their numbers are greatly reduced; they do not have sufficient opportunity for growth and the detritus on the bottom cannot now be utilised by the carp.

In a pond with a low stocking rate sufficient zooplankton will be available and far less Chironomidae will be ingested.

Having enough opportunity to grow, part of them will pupate and, ultimately, leave the econsystem, causing a loss of food.

In ponds with intermediate stocking rates less zooplankton is available and more insect larvae are eaten, but, because the stocking rate is not very high, their number is not so rapidly reduced. The larvae have the opportunity to

convert detritus into the flesh of their bodies and this food becomes available to the carp.

In this case, therefore, the minerals, originally present in the water, the basic elements of metabolism, of which a limited supply only is available during a single period of growth between filling and draining the pond, are used in the most economical way to synthesize fish flesh.

As long as the concentration of Crustaceae is high, the fish take this easily obtainable food.

When the concentration of Crustaceae is too low, the carp fails to collect sufficient for its needs per unit of time, and begins to feed from the bottom. If Chironomidae are also hard to collect, the carp will turn to snails, plant tissue and thread algae. Very big carp seem to form an exception, showing a certain preference for plant tissue in any case.

A comparison of these data with the growth curves in Fig. 5, shows that during the first period, when tiny midge larvae only are eaten, growth is slow.

During the second period, when Crustaceae are eaten, growth is rapid. In the third period Crustaceae begin to decrease and Chironomidae are ingested as well. Moreover, the amount of food needed for maintenance has also increased. At the stage when food needed for maintenance equals food ingested, no more growth can take place. In our experiments. this stage was not reached at all at stocking rates 10 and 15. At stocking rate of 20, it was almost reached. The amount of food was greatly reduced and the number of fresh Crus was very low, whereas the amount of m nance food was high. Consequently, a de in total weight of the crop would probabl place, if cropping were postponed.

At high stocking rates the amo food ingested equals the amount of mainte food from the very beginning. Both the de of the amount of food available and the in of maintenance food proceed at a slow So the danger of decrease in weight at stocking rates is small, but at optimal st rate it is of primary importance to cr pond at the right moment.

It was assumed above that growt most rapid during the time Crustaceae the main food. However, it should not ferred, from this statement, that the coe of food digestion for Crustaceae is high that for other sources of food. It even f from Karsinskin's (1935) work that Chiron are a better digestible kind of food. We on to point out that in our tanks during the at which natural food was abundant, th between the concentration of Crustacea Chironomidae was such, that the carp s the former. In the tanks with the highes the supply of Crustaceae was low and, as above, Chironomidae were ingested duri period of rapid growth as well.

At the end of the experiment the gu tents of 2 carp from each tank were exa The figures obtained were combined wi results of investigations of the faeces co at the same moment. The outcome is sh Table XII.

Table XII. Gut contents of 12 x 2 carp from concrete tanks, stocked at different rate Bogor, experssed in percentages of volume.

Stocking rate	10	15	20	35	65	100
Chironomidae	7.9	36.8	43.0	38.2	39.0	35.0
Other Insects	1.1	4.3	5.9	-	1.1	2.6
Oligochaetae	3.5	1.8	2.5	-	-	-
Crustaceae	72.5	45.2	48.2	62.5	60.2	63.0
Plant tissue	16.5	22.5	-	0.5	0.5	0.5

These results are not in accordance with obtained in Experiments II and III. In ıstance the larger carp from the lower d tanks have eaten a large percentage nt tissue. Moreover, as the number of ıceae was still fairly high, they hardly ı Chironomidae.

At the intermediate rates of 15 and 20 er tank, the number of Crustaceae was low ɜ water as well as in the guts. At the ng rate of 15, the deficit of Crustaceae is y Chironomidae and plant tissue, at the il rate of 20, by Chironomidae alone. These were eaten in maximum quantities at stocking rate. At each of the higher -35, 65 and 100 carp/tank—Crustaceae d about 2/3rds of the total quantity and ıomidae about 1/3rd.

It is surprising that at those high stocrates, at which hardly any growth occurlo other food was taken.

Probably the carp from these tanks, were ɔo small, 2 grams, to eat such coarse food ils, thread algae and plant tissue.

As mentioned before small differences natological conditions between the periods which the experiments were carried ave to be taken into account.

Similarily, small differences in the ecolo- conditions of the tanks may exist in ourse of a single experiment.

Thus, the second parallel of stocking 10 showed a heavy growth of Spirogyra ing in a very low development of phyıkton.

DISCUSSION

The general trend of metabolic processes arp pond may be described as follows :

After the pond has been filled with rich in particulate organic substances acteria, the silt will settle on the bottom. h protozoan fauna and bacterial flora develop on this silt, liberating minerals. ɔver, Chironomidae and Oligochaetae will ɔp, converting the detritus into the flesh eir bodies and again liberating a certain nt of minerals with their excreta.

These animals are eaten by the carp hus partly converted into fish flesh. The ta of the carp will liberate a fair amount of minerals into the water and thus form the basis for the development of phytoplankton. On this group zooplankton will grow, serving as food for the carp. The above processes take their course during the first two weeks.

Part of the faeces of the carp and all plankters dying from natural causes will settle on the bottom, contributing to the food for the bottom fauna. Using the minerals liberated in the mud on the bottom, an algal bottom flora will develop, mainly Diatomeae. These algae, together with the detritus mentioned above, form the food of the bottom fauna and the latter, in turn, is eaten by the carp.

However, in these metabolic cycles certain "side tracks" occur; organisms are not or hardly eaten by any other animal in the pond. Lebistes, frog-larvae, snails and thread algae are a case in point. The latter two organisms are sometimes eaten by the carp to a slight extent. Lebistes, frog-larvae and snails will accelerate the circulation of minerals because they eat other organisms, but together with Spirogyra they tend to accumulate minerals in their bodies, making them unavailable for vegetable organisms, in other words unavailable for further synthesis.

All biota in the pond fluctuate in numbers for the reasons described above. Gradually more and more minerals will be incorporated, either in fish flesh or in the "side tracks", and the amount available for circulation will gradually decrease. For this reason less phytoplankton will be formed in course of time and consequently also less zooplankton.

This is what happens in the fourth week. Bottom algae still abound at the end of the month, so the number of detritus-feeding animals on the bottom can still increase, unless they are too rapidly devoured by the carp.

According to Buschkiel (1938) the ideal type of a European carp pond is a pond showing a heavy bloom of phytoplankton, which upon decaying at the bottom after death, is eaten by a large number of Chironomidae serving as food for the carp.

This hypothesis is based on the assumption that large numbers of Chironomidae will occur in a pond whenever there is sufficient food for them. So the amount of phytoplank-

ton or its rate of growth is here deemed to be the limiting factor.

This might be the case in Europe, but the question arises whether this type of pond exists in the tropics.

According to Beauchamp (1953) the process of assimilation in the tropics is too rapid ever to become a limiting factor.

Such a factor must be sought in the katabolic part of the metabolic cycle : in the herbivorous animals mineralising the large amount of organic matter formed.

In our case the part of the herbivores is played in the water by Rotatoria, Crustaceae and frog - larvae and in the mud by Chironomidae, some other insects and their larvae, Oligochaetae and snails.

Conversion of phytoplankton into zooplankton seems to be a most rapid process in our carp ponds, as we have seen that fluctuations of the phytoplankton are closely followed by similar ones of the zooplankton.

However, a large number of Diatomeae is left untouched on the bottom.

The limiting factor seems to be the number of detritus-feeders, their rate of growth and their propagation. Oviposition of Chironomidae, propagation of Oligechaetae and the rate of growth of either group seem to be too slow to mineralise the amount of organic material on the bottom.

Only once the present author witnessed an outburst of Chironomidae, following a heavy bloom and decay of *Euglena sanguinea* in a very small and heavily manured pond in which production of fish was very high.

By comparing the influence of different stocking rates we have seen that in understocked ponds a fairly large amount of minerals is circulating slowly, in optimally stocked ponds a very small amount is circulating somewhat faster and in overstocked ponds a large quantity circulates very rapidly. The explanation was sought in the difference between maintenance food and growth food. If a certain kind of food is used for maintenance, the minerals will be excreted to a large extent; if it is used for growth, minerals will be incorporated and withdrawn from circulation. This relation explains why development of plankton continues until the end of the period in the case of high rates (Fig. 7, stocking rat
However, sometimes the concentration
plankton is insufficient for large carp, an
Chironomidae are eaten as well. As these
are unable to develop quickly enough
numbers and total volume are decr
towards the end of the period.

The investigations of Vaas and Va
Oven (to be published elsewhere) concern
composition of the gut contents of the c
carp during growth show that in c
increasing size the number of Crustaceae
guts is low, each time the pond had been
with water, it increased afterwards u
optimum is reached, and finally it decrease

The number of Chironomidae was
to rise more slowly towards the end
period or to show a less definite optimum

Although no concomitant limn
data were available, there are perhaps
tions that, in the case of these carp too,
number of Crustaceae was present som
after the pond had been filled, and
decrease followed afterwards. In so
stances Chironomidae must have been pl
showing an optimum in others. Here o
ponds were used, with slowly running
and with a heavy supply of organic m
while the carp were given some bran a
yet a strong similarity with our concret
could be noted. In spite of the simplifi
ditions in our experiments, we may assu
metabolic cycles proceed along similar l
most instances of ordinary ponds fed wit
containing a good deal of particulate
matter.

From our calculations of grow
ultilisation of food we concluded that t
quantity of food ingested by the entire
tion rose as the stocking rate increased
The question was raised at that stage w
this had to be explained by assuming t
total quantity of food was larger, or whet
utilisation of food was better. In or
evaluate food production certain limn
investigations were carried out. Howe
are not yet in a position to give a
answer, owing to our lack of knowledg
the average life time, the rate of growth
propagation of the various organisms inv

In a general way it may be stated that isms in a tropical pond will differ from isms in one in the temperate zone, in the ing ways: the life span will be shorter, te of growth will be higher, the propaga- ill be more rapid, but the ultimate volume imal will be smaller. The total quantity ustaceae will be at a maximum in ponds ed at the highest rates. The large amount idly circulating minerals gives rise to a bloom of phytoplankton and consequently well developed zooplankton. Crustaceae e at a minimum in optimally stocked ponds he total quantity in understocked ponds e in between these two values.

The volume of Chironomidae hatched the entire period of growth decreases increasing stocking rates. As it must be ed that the number of eggs deposited in onds is constant, we can infer that the are so quickly devoured in heavily ed ponds, that they do not have the oppor- to get ahead.

When phytoplankton is well developed and nkton is growing rapidly, we must assume usually the increase in volume of the aceae exceeds that of the Chironomidae. it would follow that the total supply tural food is maximal at overstocking, al at optimal stocking and intermediate stocking rates.

It is surprising at first sight to have to e that the total production of natural food s in an inverse relation to the total yield of esh but this relation will be explained in llowing paragraphs.

The difference between the total quanti- f food ingested at various stocking rates r than the optimal one is a result of the hat the supply was maximal at the highest But this does not yet explain the differ- between the amounts ingested in the with low stocking rates. Here the total nt of food formed was higher, therefore e led to believe that part of it was left ched, as we have seen that many nomidae were not ingested (situation at tocking rates, shown in Fig. 8 and 9).

We may however look at the "availability d" from another angle.

From all our considerations we concluded that the part played by dissolved minerals is of primary importance for all metabolic cycles in the pond. There will hardly ever be a high concentration of dissolved minerals in the water, because they are incorporated into phytoplankton immediately after they have been released, thus they ultimately determine the rate of all metabolic processes.

Nearly the only source of minerals is the water supply, or rather, the particulate organic matter in which minerals are still enclosed. Moreover, the total amount of mineral matter in the tanks is slightly increased in course of time by leaves falling in. However, the total amount is quite independent from the way of stocking and can be seen as constant throughout. At too low stocking rates minerals circulate so slowly that not much organic matter is formed. A good deal is taken up by animals that are not eaten themselves.

At too high stocking rates the minerals are constantly used for the formation of new maintenance food. Besides, a part of the minerals remains on the bottom without being of any further use. It is incorporated into bottom algae that are not eaten by the bottom fauna, because the animals constituting this fauna are eaten too rapidly by the carp. Part of the minerals will be absorbed by snails. These snails subsist on bottom algae, but are not often eaten themselves. In a way "side tracking" organisms also profit by the rapid circulation. At optimal stocking rate the minerals are taken up by the fish at the most rapid rate. The part of the minerals that settles on the bottom is also used, because Chironomidae and other members of the bottom fauna are still present to consume it. But since minerals are stored by the carp to a large extent, the "side tracks" do not have much opportunity to get hold of them.

Natural food decreases quickly in the course of the growing period and the rapidly increasing fish population needs a lot of maintenance food.

The optimal stocking rate is characterised by rapid conversion of minerals into fish flesh, rapid growth during the second and third period of 8 days and rapid decline of the growth rate during the next period.

SOME CONCLUSIONS IMPORTANT FOR PRACTICAL POND CULTURE OF THE COMMON CARP

1) It is most important to ascertain the optimal stocking rate.

The total yield falls rapidly at decreasing stocking rates. In the event of overstocking the total yield will decrease much slower, but the danger of losses will increase. A correct rate of stocking means an economic use of fry. By finding the total number and the total weight of fish at the time of stocking and of cropping, it is possible to obtain the data necesary to determine the optimal rate for carp of different size in every pond complex. Calculations based only on an estimation of the yield, a desired weight of fish or a desired duration of the growing period, are apt to cause great disappointments because the total yield depends on the duration of the period, on the stocking rate and on the initial weight of the stocked material and may not be seen as a constant characteristic for a certain pond.

At high stocking rates the total yield cannot be increased by a prolongation of the growing period.

2) No correct estimation of the total yield can be made by determination of the quantity of plankton only.

3) On the basis of an analysis as referred to above, limnological improvements in the pond may be effected, causing an increased yield of fish.

In the situation described, the limiting factor seems to be the number of animals eating the bottom-detritus, such as Chironomidae and Oligochaetae. Chironomidae might be attracted by the use of small tanks full of decaying vegetable material, situated near the pond. Another way might be the use of Oligochaetae, cultivated separately in tanks and added to the ponds.

Still another way might be to try to eliminate the "side tracks" by introducing animals, preferably other fish, living on them.

In our case the "side tracks" were: frog larvae, Lebistes, snails and Spirogyra. The introduction of fish feeding on these organisms might be beneficial.* It will be diffi eliminate frog larvae and Lebistes in thi as the introduction of predatory fishes is the question. Still the eradication of L merits attention, as this fish is not only track" but also a competitor for food. case, the introduction of Lebistes for la purposes in regions where this species absent and where Common carp are raised be avoided.

4) An obvious way of improving increase of the amount of minerals av Next to the use of fertilizers havi disadvantage of high cost and caus intensive bloom of phytoplankton wi concomitant danger of absorption of at night time, the use of green manu stable manure might be considered.

Some of the improvements me above are being examined at the prese in our Laboratory. The preliminary re some of these investigations will be pu in another paper.

SUMMARY

1) In concrete tanks the optima and individual growth of carp fry at stocking rates was studied, together w influence of the fish on the metabolic in the tanks.

2) Connections between stockin individual growth and total yield are in Fig. 2 and 3.

3) The individual growth of c various stocking rates are illustrated in F

4) The relationship between fo gested, maintenance food and food avail growth for the entire population was c ted. The results of this calculation ar in Fig. 6. It appears that the amount ingested rises with increasing stocking as does the amount of food needed for m nance. At the stage where the differen ween these two values reaches a ma we find the optimal stocking rate.

5) It was inferred from limnolog vestigations that the amount of food in the tanks was maximal at high st rates, minimal at optimal stocking rat

* The Indian carp, *Labeo calbasu* (Ham.) and the Chinese black carp, *Mylopharyngodon piceus* (Rich are reported to eat snails.

nediate at low rates. These relations explained by assuming that minerals are porated rapidly at optimal stocking rates for this reason, are no longer available he phytoplankton (Fig. 7 and 8).

6) From a consideration of the connec- between limnological data (Fig. 7 and 8) he gut contents (Fig. 9), we concluded at the optimal stocking rate the availa- od is utilised to the best advantage, and minerals are most rapidly incorporated e carp into the flesh of their body, thus nting those minerals from being absorbed rganisms not eaten by the carp or by animals in the ecosystem ("side tracks").

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Table I. Experiment I, II, III. Individual growth and total yield per tank.

(Horizontal rows represent 3 different parallels, but 6 for stocking rate of 60, as at this rate Experiment I and III overlap).

Stocking Rate	3	10	17	20	24	30	40	45	60	75	80
Individual growth in grams	24.6 38.2 33.6	16.0 15.2 17.2	13.1 10.0 8.5	12.2 12.2 12.2	5.8 7.0 4.9	7.1 7.0 6.3	4.2 4.6 3.1	6.0 3.7 5.7	2·1 2.7 3.9 3.7 4.3 1.8	3.4 3.3 2.0	1.3 1.0 1.0
Total yield in grams per tank	77.9 144.6 100.0	159.4 151.8 171.7	197.5 171.4 134.2	215 230 230	159.7 138.1 95.6	205 210 180	165 160 115	235 125 235	165 160 175 175 125 110	170 245 135	100 50 55

Table II. Experiment IV. Individual growth and total yield per tank.

(Two paralells for each stocking rate).

Stocking Rate	10	15	20	35	65	100
Individual growth in grams	13.7 21.7	10.0 12.9	9.0 5.7	4.2 5.0	2.2 1.5	1.0 1.6
Total yield in grams per tank	122 149	140 179	170 200	119 183	135 88	72 84

Table III.

Correction table to be used when initial weight and ultimate weight only are known. *(For explanation see text).*

Individual growth in grams	Average 5 intermediate weights in grams	Average initial and ultimate weight in grams	Correction factor
17.5	8.1	9.7	0.83
11.5	5.8	6.7	0.86
7.6	4.7	4.8	1.00
5.3	3.3	3.1	1.00
2.6	2.1	2.3	1.00
1.3	1.6	1.6	1.00

Table V. Actual individual growth, compared with theoretical individual growth assuming that all food available were used.

1	2	3	4	5	6	7
Stocking Rate	Amount of food available per fish in *U*	Maintenance food needed per fish in *U*	Food available for growth in *U*	Growth in grams calculated	Growth in grams measured	Difference 5—6
10	17.50	4.20	13.30	47.2	15.0	32.2
20	8.70	3.00	5.70	24.5	9.0	15.5
40	4.40	2.10	2.30	9.9	4.0	5.9
60	2.90	1.70	1.20	5.2	2.3	2.9
80	2.20	1.45	0.75	3.2	1.4	1.8
100	1.75	1.30	0.45	1.9	1.0	0.9
120	1.45	1.20	0.25	1.1	0.6	0.5
150	1.20	1.15	0.05	0.2	0.2	0.0
175	1.00	1.00	0.00	0.0	0.0	0.0

Table IV. Growth and food at different stocking rates.

Stocking Rate	Individual Growth in gram	Average weight in gram	Average length in cm.	$\frac{\text{Weight}}{\text{length}} = Q$	Maintenance food in U $\left(\frac{Q}{0.31} \times \text{st. rate}\right)$	Total yield per tank in gram	Food used for growth in U $\frac{\text{Total yield}}{4.3}$ (calculated)	Total amount of food ingested in U (calculated)
Experiment I,II,III								
120	0.0	1.50	3.60	0.42	165	0	0	165
100	0.6	1.80	3.75	0.47	151	60	16	167
80	1.2	2.10	4.08	0.51	131	196	22	153
60	2.6	2.80	4.50	0.62	120	156	33	153
40	4.9	3.95	5.00	0.80	103	196	45	148
20	10.0	5.40	5.50	0.98	63	200	46	109
10	14.6	7.50	6.00	1.20	49	146	33	82
Experiment IV								
175	0.0	1.00	3.20	0.31	175	0	0.0	175.0
150	0.2	1.10	3.25	0.34	168	30	7.0	175.0
120	0.6	1.30	3.40	0.38	147	72	16.5	163.5
100	1.0	1.50	3.60	0.41	130	100	23.0	153.0
80	1.4	1.70	3.80	0.45	116	112	25.5	141.5
60	2.3	2.15	4.10	0.52	101	138	31.5	141.5
40	4.0	3.00	4.60	0.65	84	160	36.0	120.0
20	9.0	5.20	5.50	0.99	60	180	41.0	101.0
10	15.0	8.50	6.50	1.31	42	150	34.0	76.0

ıble VI. Most important genera found in the Plankton of 12 concrete tanks in Bogor.

nkton	
vocales	
Pandorina	+ +
orococcales	
Dictyosphaerium	+ + +
Golenkinia	+ +
ijugales	
Cosmarium	+
ıthopyceae	
Botryococcus (incidental)	+ + +
ıtomeae	
Navicula	+ + +
Melosira	+ +
ıophyceae	
Peridinium (incidental)	+ + +
oromonadineae	
Euglena	
ınophyceae	
Microcystis	+
Oscillatoria	+
Protozoa	
Arcella	+
Difflugia	+
Ciliates (unidentified)	+
Rotifera	
Brachionus	+
Monostyla	+
Polyarthra	+
Asplanchna	+
Crustacea	
Nauplius larvae	+ +
Bosmina	+
Cyclops	+ +
Diaphanosoma	+ +

Table VII. Most important organisms found in the mud of 12 concrete tanks in Bogor.

ronomide larvae	
Chironomus	+ +
Tanytarsus	+ +
Eutanytarsus	+ +
Paratanytarsus	+ +
Tanypus	+ +
Protenthes	+
emeridae larvae (Not identified)	
ochaetae	
Nais	+
Aulophorus	+
Pristina	+
Branchiodrilus	+
Dero	+
Limnodrilus (incidentally)	
Mollusca	
Vivipara	+ +
Melania	+ +
Diatomeae	
Navicula	+ + +
Melosira	+ + +
Cymbella	+ +
Pleurosigma	+ +

Table X. Experiment I. Organisms found in the guts of 12 × 2 carps, expressed in percentages of volume.

Stocking / ta	20	40	60	80
omidae	44.8	24.2	28.4	4.7
insects	1.7	2.2	9.9	4.2
cea	40.0	46.4	41.5	39.0
iaetae	—	0.1	—	—
poda	1.2	—	1.1	2.8
issue and ead algae	12.3	27.2	19.2	80.0

Table XI. Experiment II. Organisms found in the guts of 12 × 2 carps, expressed in percentages of volume.

Biota \ Stocking	3	10	17	2
Chironomidae	32.0	31.6	22.3	9
Insects	4.9	13.4	4.2	6
Crustacea	52.5	52.0	59.2	55
Oligochaetae	—	0.8	0.5	0
Gastropoda	—	—	—	3
Plant tissue	10.3	1.1	13.3	25
Thread algae	0.2	0.1	0.2	—

:D CONTROL IN FARM POND AND EXPERIMENT BY STOCKING GRASS CARP

by

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ABSTRACT

Consideration was given to the ill effects of excess growth of aquatic plants on productivity of fish in farm-ponds, and the methods of control currently practised.

On three farm ponds an experiment was carried out to test weed control by :king with Grass carp, comparing the abundance of vegetation of each pond with and hout stocking. The total fish production was also traced along with the Grass carp eriment.

It is tentatively stated that Grass carp numbering over 30 and weighing over 35 . if stocked for each ha. of water, will curb the growth of the weed, especially submerged nts. within one year in an ordinary farm pond. It was also shown in the experiment t the stocking of Grass carp did not diminish the total fish production of the pond, ugh some effect was apparent according to the species among the whole fish ulation.

TIC VEGETATION AND ITS CONTROL

Excessive growth of aquatic vegetation, er floating or submerged in farm ponds desirable and often is harmful. The antages are: 1) absorption of nutritive n water (Matida, 1955 and 1956), 2) curb- e growth of plankton, (Suginome and 1949; Olson, 1932 and Rounseffel and art, 1953), 3) preventing the rising of :ature of the water (Hata *et al* 1949), nvenience in harvesting the fish (Naka- 1950 and Nakamura *et al* 1954), 5) aiding owth of small fish which are not a y objective in production, and providing for undesirable insects (Edminster, 1947, verhart, 1953.). Our experience in the lso revealed that the excessive growth atic plants results in the eventual filling pond by the accumulation of dead plants, aning out of which requires extra labour part of the fish farmers.

The methods and procedures of weed control in farm ponds which are reported in a number of publications may be classified into four major categories—mechanical cutting, fertilization of water to help the growth of plankton, the use of herbicides, and the use of herbivorous fish, and on these subjects reference will be made to the reports, for instance, of Rounseffel and Everhart (1953), Edminster (1953), Nakamura *et al* (1954), Hogan (1946), Meehean (1945), Matida (1955 and 1956), Surber (1947), Compton (1943), Matsue (1947), Snow (1949), and Lawrence (1956).

The evaluation of various methods of weed control such as those reported, however, is not necessarily simple, because any method or procedure proposed always involves mechanical, biological and chemical problems in varying degrees, and the latter two factors especially, are not yet well understood. Moreover, the general environment of farm ponds varies from one to another, in addition to the very basic problem of the economies of fish production from the pond.

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Table I. Effect of Grass carp stocking on the abundance of vegetation in three farm po Nagano Prefecture.

The abundence of vegetation is expressed as surface pond covered by vegetation: A—ov B—20-50%, C—less than 20% and D—Nil
Density of vegetation: c—high, f—medium, r—low n—zero,

Pond	Surface area in ha.	Max. depth in m.	Year	Stocking	Abundance of vegetation				
					Apr.	May	June	July	Aug.
Maeik	1.85	3	1951	No	— —	B f	A f	A f	A f
			1954	Yes	B f	B c	A c	A c	A c
			1955	Yes	C f	C r	D n	D n	D n
Onnaike	0.85	2	1951	No	A f	A c	A c	A c	A c
			1954	No	A c	A c	A c	A c	A c
			1955	Yes	C r	D n	D n	D n	D n
Nakanoike	1.82	3	1951	Yes	— —	B f	A f	A c	A c
			1952	No	A f	A c	A c	A c	A c
			1955	Yes	— —	A c	A c	A c	A c

Japanese experience and practice of farm pond fish production has not yet been able to achieve a highly efficient method of weed control which satisfies the economy of fish farmers. In general terms, the cutting of weeds, always done by manual labour, is not effectively accomplished by farmers for whom owing to the high labour costs, the use of fertilizer for the purpose has not been technically successful; the use of herbicides is far from the reach of farmers in their economy.

Under such circumstances weed control by means of herbivorous fish, the last item in the four methods of control, has recently invited attention, though Japan has not abandoned the possibility of devising an effective method falling within the remaining three categories.

The present paper will report a recent experiment (1954 to 1956) on the stocking of Chinese Grass carp *(Ctenopharyngodon idellus)* into three farm ponds as a weed scavenger. Despite the incompleteness involved in various items in the experimental procedure, it is felt that this method of biological weed control will be applicable to fish ponds whether natural or operated by a fish farmer.

WEED CONTROL BY FISH

Hogan (1946) suggested the pos of weed control by stocking Common c an excessive number, the fish stirring bottom soil and making the pond water thus interfering with the photosynthe the aquatic plants. Our experience (1 lished), however, did not support the proposed by this author.

The use of Grass carp for the p has already been reported by us (Nak 1950 and Nakamura *et al* 1954), an mentioned by other workers including (1953), Araki (1943) and Hata *et al* (19 was also pointed out by Nakamura (1954) that the stocking of Grass ca not alter the tolal fish productivity, in a farm pond, composed of Common car Gold fish and shrimp. In the experime weed control by Grass carp, reported by workers, the sample fish used were t dividuals which had survived from those were introduced from Shanghai in or 1954 (Kuronuma, 1954). With the reo of Grass carp fry import from Hongk 1954, the present writers decided to the experiment by using these fish a seek a more definite conclusion.

EXPERIMENT

The three farm ponds tested in the
at experiment, Maeike (1.85 ha. in surface
Onnaike (0.85 ha.) and Nakanoike (1.82
are irrigation ponds located in the Shioda
470 m. above sea level in Nagano
cture. These ponds, nearly quadrangular
ape, hold the water at maximum depth
to 3 m. with some fluctuation of water
especially in August and thereafter. The
al procedure of fish farming in the pond
ollows : the fish fry (Common carp and
Gold fish) are stocked either in fall, after
arvest of the year, or in spring, and
ater level of the pond is lowered usually
e time of the fish harvest in fall. At
ccasion fish farmers clean out by hand
ubmerged plants within their allowance
our. The crop of shrimp *(Leander pauci-*
is derived entirely from natural produc-

The amount of fish harvested in a given
n a pond is, to a certain extent, affected
e quality and quantity of fish fry stoc-
the year, though, theoretically the fish
ction protential should be consistent in
l. The temperature of pond water reaches
aximum of 30°C in mid-summer (August)
and drops down to 1°—0°C in mid-winter of January or February, when it is usual to see the surface water completely frozen.

The aquatic plants growing in these ponds are of numerous species, but dominant among them are:

Submerged plant —
- Parrot feather *(Myriophyllum specatum)*,
- Horn wort *(Cratophyllum demersum)*,
- Pond weed *(Potamogeton* spp.*)*,
- "Kuromo" *(Hydrilla verticillata)*,

Floating plant —
- Water chest-nut *(Trapa* spp.*)*

Marginal plant —
- Marsh weed *(Phragmites communis)*,
- "Ukiyagara" *(Scirpus maritimus)*,
- Water oat *(Zizania latifolia)*

The immediate shore of the ponds is vegetated in a similar pattern by three kinds of plant listed above; however, the submerged and floating plants are varied in abundance and species from pond to pond. At the present time there is no way to indicate the amount of vegetation growing in the pond, although this had a highly significant bearing on the problem of weed control.

le II. Record of Grass carp stocking in three farm ponds in Nagano Prefecture showing amount of stocking and harvest.

	Stocking			Hervest	
	Date	Number of fish	Weight in Kg.	Date	Number of fish	Weight in Kg.
	1954			1955		
	Oct. 20	93		Sept. 26—30	218	161
e			6.9			
	1955			1956		
	Apr. 8	162		Oct. 2	101	120
	Oct. 8	111	82.0			
ce	1955			1956		
	Sept. 26	50	34.0	Nov. 14	47	71
oike	1955			1956		
	Nov. 7	100	30.0	Oct. 5	79	145

Each pond was stocked with Grass carp (Table II) and the liberation of fry of other species was also made in the usual way. The Grass carp were kept in the pond about one year and harvested together with the other species when the level of the water was lowered in the fall. The actual results of the weed control by the fish were estimated by comparing the abundance of vegetation in the years of experiment with that of the previous years when no Grass carp were stocked (Table I).

As to the actual evaluation of weed control we have adopted two procedures: 1) the visual examination of the abundance of plants in the water, aided by photography (Figures on Plates), and 2) the amount of the farmer's labour, when the water level is lowered, required to clean out the bottom vegetation (two ponds only). By visual examination the abundance of the vegetation was expressed by symbolic letters of two kinds — A, B, C, D and c, f, r, n — which are explained in Table I.

RESULTS AND DISCUSSION

The stocking of Grass carp to each pond tested and the crop of fish one year later are shown in Table II expressed in number and total weight of fish, and the abundance of vegetation in each pond with and without the stocking of Grass carp is presented in Table I where the result of visual examination is given by month (April to September). The pictures in Plates I to III also illustrate the vegetation in each pond before and after the stocking.

Maeike

Into this pond Grass carp numbering 255 (6.9 kg.) were stocked in October, 1954 and April, 1955, and the harvest made in September, 1955 yielded 218 fish weighing 161 kg. Again in October, 1955, 111 fish (82 kg.) were stocked and 101 fish (120 kg.) were cropped in October, 1956. Therefore, the result of weed control was observed during 1955 and 1956.

In our visual examination of vegetation of 1955 we found apparently no sign of thinning of the grass compared to that of previous years, instead, the water chestnut had grown heavier. However, it was revealed that, after the lowering of the water in September, the growth of submerged plants was well controlled (Fig. 2) resulting in the decrease of farmer's labour from 10 to 15 man-days in previous years (with no Grass carp) to only one day in this year. The total effect of Grass carp stocking on weed control was estimated 70% in this pond in 1954-1955.

In 1955-1956, the second year of experiment, the vegetation showed very little growth (Table I) by April and May, 1956. Thence the vegetation in the pond was so thin that repeated attempts to collect bottom vegetation by dredging failed. The marginal plants were also held down in this year. The new buds of the year were eaten, but the older stems of plants (of the previous year) remained unbranched; the marginal portions of the floating leaves which were immersed in the water were also eaten. Such feeding habits of the Grass carp were also noted by Fujita (1955).

Onnaike

Previously the Onnaike pond had been filled with thick vegetation consisting of Pond Weed, Parrots Feather, Horn Wort and "Kuronuma" as submerged plants and Water Chestnut as the dominant floating plant, and efforts to control the excessive growth whether by cutting or fertilizing seemed to have no effect (Nakamura *et al* 1954 and Mizuno 1955). Moreover, the growth of water chestnut was believed to be accelerated by the fertilization of pond water.

In November, 1955, 50 Grass carp (3 kg.) were stocked and the harvest yielded 4 fish weighing 71 kg. in November, 1956. The effect of weed control by the fish was very remarkable in this pond, estimated at 100% in the observations in May, 1956, the vegetation of the pond water was represented by very small growth of Water chestnut along the shore, but, thereafter, the plants in the water were believed to be completely eradicated judging from the fact that repeated efforts by dredging the bottom failed to collect any growth (Pl. III, Fig. 5). The marginal plants, however, showed no sign of decrease in density whether in the air or in the water.

Nakanoike

Formerly, the Nakanoike pond contained submerged plants so thick that the children of a nearby village were afraid to bathe in the water, and the efforts made by the peo

the growth of bottom vegetation were . In 1951, 17 Grass carp were liberated e water, but no sign of weed control was nt.

In November, 1955 one hundred fish g. in total weight) were stocked in the and 79 fish weighing 145 kg. were har- d in October, 1956. The effect of the s carp stocking, however, was not so signi- t as was expected. Up to July, 1956 visual ination suggested that the bottom vegeta- was noticeably thinned out in the water ially in the vicinity of the outlet gate, n the rest of the pond water the vegeta- especially Parrots feather had grown thic- han in previous years. However, from the part of August to September it appeared the submerged plants were being eaten by s carp, because small pieces of plants and s were observed floating everywhere on the ce of the water. When the water was ed (late October) it became clear that the growth of the bottom weed had been curbed by fish; the farm labour required 8 man-days in previous years when no Grass carp were stocked. The over-all effect of the fish stocking was estimated at 70% in this case.

Efficiency of weed control by grass carp

The results of the experiment suggest an answer to the question of the Grass carp for weed control *i. e.* how many fish should be stocked in order to expect satisfactory control of the weed in a farm-pond ? Theoretically the analysis of the problem will cover two major categories; firstly, the quality and quantity of plants in the pond, secondly, the feeding activity of Grass carp. Further, each of these two categories contains a number of factors of both biological and limnological nature. It is realised that until each of many factors is adequately understood it may not be possible to arrive at a full solution of the problem.

Table III. Weed control by Grass carp in farm ponds in Nagano Prefecture.

ace .)	Stocking of Grass carp Year	Number of fish in ha.	Weight of fish in ha.	Result of Control in %	Source
ke	1954	138	3.8	75	Original
)	1955	60	44.0	100	
ike)	1955	50	35.0	100	,,
noike 32)	1951	9.3	21.0	0	Nakamura *et al* (1954)
	1955	55	19.0	70	Original
	1948	29	21.0	90	Nakamura *et al* (1954)

The present experiment is far from ing a true understanding of the problem r in the procedure of experiment or in analysis of the data derived. Especially nt is the lack of an accurate method in uring the amount of vegetation growing e water before and after the stocking ass carp. Knowledge of the feeding habits iological and ecological) of the fish also is inadequate. Answers to these subjects have been given by fisheries workers such as Nakamura (1950), Tauchi (1953), Araki (1943), Aoki (1953) and others, but the answers given are not necessarily convincing.

Within the limits of the experience gained in the present experiment and in the past we may touch here briefly on the efficiency of the Grass carp as a means for weed

control *i.e.* how many fish are needed. In Table III. the amount of fish stocked and the estimated results of weed control are listed in the six experiments on four farm ponds. For the interpretation of the data, it must be assumed firstly that the amount of vegetation in each pond was approximately the same during the years of testing, and secondly that the amount of aquatic plants eaten by Grass carp is proportional to the number or weight of fish stocked.

Under such assumptions it appears that a stock of Grass carp amounting to over 35 kg. in total weight and over 30 in number to each ha. of surface area of pond is required in order to ensure satisfactory control.

It is clear that such a statement is merely tentative, and may not be tenable when freshwater bodies of different characters or different types of aquatic plant are under consideration.

FISH PRODUCTIVITY

As pointed out elsewhere in the report the final objective of Grass carp st is the increase of total production of fish water by controlling the excess grow plants. If stocking with Grass carp r in the decrease of total productivity water they would have no value as a control agency. But if the Grass car grow by feeding on the aquatic pla the water without lowering the produc other species of fish Common carp, wil fish and shrimp in Japan the harvest Grass carp may be interpreted as "extra in to fish farmers. In our test of the Oik the stocking of Grass carp increased th fish yield (Hata *et al* 1949 and Nakamu 1954).

Table IV, Yearly production of fish in three farm ponds in Nagano Prefecture by s in percent of total amount for the year.*

Pond (Surface area in ha)	Year	Total amount in l.c.	Production in			
			Common carp	Wild gold fish	Shrimp	Grass carp
Maeike (1.85)	1952	678.0	24.8	59.1	16.1	0.0
	1953	520.0	34.4	46.9	18.8	0.0
	1954	654.0	38.7	47.6	13.8	0.0
	1955	719.0	38.2	39.1	10.3	22.4
	1956	634.0	27.9	44.2	8.7	18.9
Average		641.0				
Onnaike (0.85)	1951	233.0	22.2	31.2	46.8	0.0
	1952	432.0	13.3	63.9	22.8	0.0
	1953	398.0	9.7	72.6	17.8	0.0
	1954	424.0	10.9	65.6	19.9	0.0
	55+56	918.0	1.1	98.0	0.1	0.8
Average		400.8				
Nakanoike (1.82)	1945	391.0	31.9	35.9	32.2	0.0
	1946	470.0	18.6	46.1	35.3	0.0
	1947	409.0	29.8	38.6	32.0	0.0
	1950	515.0	23.3	53.2	22.9	0.0
	1955	478.0	25.1	49.4	25.1	0.0
Average		491.3				

* Source : Original and Nakamura *et al*, 1954.

n Table IV we present the yearly pro- of fish in the three farm ponds on the present experiment was carried out. analysis of the data given here it e pointed out that the figures of pro- do not show necessarily a true picture ield in a given pond in a year, because of fish fry (Common carp and wild Gold ocking varies, though to a small extent, and by year. Nevertheless, the annual ion of the ponds is quite stable showing ation of perhaps less than 20% in Maeike kanoike. In the case of the Onnaike fertilized in the three years 1952 to he fish yield showed 40% increase in ee years over that of 1951 when no r was applied. It is apparent, however, sh production of the pond was quite lur g these three years.

Within the data presented in Table IV ot so clear whether or not the harvest ss carp may be interpreted as "extra" ion of the water, but it seems apparent e Grass carp do not affect adversely r-all fish production in the farm pond. t is also apparent that the stocking ss carp diminishes the production of n carp and shrimp, but this is compensa- by an increased harvest of wild Gold fish. terpretation of this fact cannot be given ly until the biology of each species ed is well understood, but it may not be erroneous to believe that the eradica- bottom vegetation by Grass carp is responsible for the dwindling of the population which finds its natural habi- he mass of aquatic plants on the bottom. he relation of Grass carp with Common nd wild Gold fish Present data do not an adequate explanation.

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ure 1. The Maeike pond with water lowered in October, 1952. No grasscarp stocked. Piles of submerged plants which were cut down by farmers are seen.

ure 2. The same pond, is October, 1955, but water lowered. Piles of cut down plants are few. Compare to Figure 1.

Figure 3. The same pond in the same year but water completely drained, showing submer plants completely eradicated.

Figure 4. The Onnaike pond showing thick vegetation of water chest-nut in October, 1955. grass-carp stocked.

ure 5. The same pond in October, 1956. The fish stocked cleared out Water Chest-nut.

ure 6. The Nakanoike pond with water drained in October, 1953. No grass-carp stocked. The piles of submerged plants cut down by farmers are seen.

SHOULD THE TIME OF FOOD SUPPLY BE CONTROLLED IN FISH CULTURE?

by
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ABSTRACT

Many reports have been published on the correlation between fish growth and ds of food material. However, no attention has been paid to the time of food supply, nough it is easily presumable that fishes have a diurnal rhythm and also annual iation in feeding activity peculiar to each species. Most fish culturists control the e of food supply on the basis of experience or on the basis of their own conve- nce in management. The authors believe that unless the time of food supply is con- led having concern for both the physiology and behaviour of the fish concerned, no onal fish culture can be established. Evidence is presented that the diurnal rhythms the feeding activity are clearly recognizable in both the goldfish and rainbow trout and that these are heavily distorted by the changes of certain environmental factors.

NOTES ON GROWING OF 'LAB-LAB' IN 'BANGOS' NURSERY PONDS

by
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ABSTRACT

Difficulty in growing 'lab-lab' used for feeding milkfish *Chanos chanos* fry and ger lings has been solved by the use of organic fertilizers. Rice bran, locally called rak', was used in this study as fertilizer to increase 'lab-lab' growth. Experiments wed that 'lab-lab' can be grown abundantly within thirty days in the fertilized nursery id. Rice bran was scattered at a rate of 400-600 g. per square metre on the surface of wet nursery pond. Water in the pond was maintained at a depth of ten centimetres hout total change. The rice bran fermented and decayed causing a toxicity of the ter which poisoned predators Growth of 'lab-lab' started to show at the shallow edges the pond extending inwards toward the deeper portions within ten days.

During the rainy season growing of 'lab-lab' is difficult, but by using 'darak' as tilizer, it is rendered easier. 'Bangos' (milkfish) fry should be stocked within three eks to one month after rice bran is placed in the pond or when the 'lab-lab' growth it its maximum, otherwise *lumut*, green filamentous algae, takes the place of the 'lab-lab'. is is not needed in nursery ponds. The use of horse manure and chicken droppings fertilizer is also recommended.

OBSERVATIONS ON THE USE OF TERRAMYCIN AND VIGOFAC ENRICHED ON 'BANGOS' FRY, *CHANOS CHANOS* (FORSKAL)

by

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ABSTRACT

A preliminary study on the use of anti-biotics and animal protein factors in feed for 'bangos' fry was made under controlled conditions. Seven lots of 'bangos' of 1,500 each lot were fed with different formulae of dry food in controlled tanks. lots were supplemented with 0.5 per cent Terramycin and 1 per cent Vigofac as recommended by the manufacturers of these products. These were given in additio supplementary food consisting of powdered milk, rice bran, and fine corn meal in diffe proportions.

A weekly sample of five fresh fish was taken from all tanks to determine growth rate of the fry. After 17 days the fry were transferred to the nursery p leaving a small number in the concrete tanks. This formed the second series of which lasted for seven weeks on the same feeding schedule. Mortality was greates the control tank and in the tank without Vigofac and Terramycin. Growth rate greatest in the lots with nutritive dry food consisting of powdered milk, rice bran corn meal with the addition of Terramycin and Vigofac.

FERTILIZATION OF 'BANGOS' NURSERY PONDS WITH COMMERCIAL CHEMICAL FERTILIZER

by

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ABSTRACT

With the present area of no less than 106,000 hectares dedicated to the 'ba (*Chanos chanos*, Forskal) fishpond industry, the culture of 'bangos' fry is in nee improvement to increase its production and reduce mortality of fry in the nursery po Experiments were conducted by using complete chemical inorganic fertilizer to re the usual practice of depending on the natural growth of 'lab-lab' produced by fermentation of uneaten refined rice bran used as feed of the fingerlings. This l practice is not only inadequate but results in a big mortality of fry in the nursery p due to many adverse conditions, lack of food, sudden change of temperature, etc.

Fertilization of nursery ponds with complete chemical fertilizer N-P-K : 8 proved to be economical by producing abundant fish food that made possible an inc of stocking rate from 20-30 fry to 50 per square metre of pond water. At the same t it reduced the usual mortality rate from 60 per cent to nil. Chemical analysis of pond soils showed that liming before fertilization is not necessary as they contain suffi amounts of calcium and potassium. Fertilized ponds without the addition of lime ind a greater increase in the growth of fry than the other experimental ponds.

STUDIES ON FOOD AND FEEDING HABITS OF THE COMMON CARP IN INDONESIAN POND*

by

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ABSTRACT

I. Changes in the diet during growth

Experiments on food and feeding habits of *Cyprinus carpio* L. in Indonesian ponds ıow that the fry feed on: Crustaceans, Chironomides, other insects and their larvae, otatoria and Closterium from the very beginning and in their later stages also on plant ssue and thread algae. The bigger fish (40-136 mm.) feed mainly on Crustaceans, Chironomi-es, vegetable food and aquatic insects other than Chironomides. Comparison of the com-ɔsition of the food with the rate of growth of the carp and its intestinal tract together ith the ratio between length and height of the body, showed that growth is slow when :d on vegetable food.

Compared with the German Common carp the relative length of the guts of the ndonesian carp proved to be smaller.

II. The food of the Common carp in ponds in various circumstances

These are continued studies on "Changes in the diet during growth" of *Cyprinus ırpio* L. in Indonesia and results obtained in previous studies concerning the feeding abits of the Common carp were supplemented with the following evidences:

1) The difference between carp smaller and bigger than 40 mm. was emphasized.

2) The gut contents of carp from 6 different ponds compared with the supply f natural food in the ponds showed, to a certain extent, a preference for microcrustaceans.

3) The influence of the stocking rate on the diet in understocked, optimally tocked and overstocked ponds was studied.

* English translation of the *Report of the Laboratory for Inland Fisheries*, No. 19 by author.

ME NOTES ON A TENDIPEDIDE LARVA OF THE *PLUMOSUS*-TYPE FROM JAVA*

by

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ABSTRACT

Tendipedide larvae of the *plumosus*-type have been found frequently in the gut of *yprinus carpio* L., cultivated in fresh water ponds. Experiments in Indonesia on red *hironomus* larvae of this type showed that the time required for development from egg ɔ imago was 26-32 days and the percentage of mortality lay between 75.3-90.3. Measuring ıe width of the head-capsules of the larvae, four different stages could be distinguished; ıorover, morphological differences between these stages were found. The average lifetime f these stages were: Embyro: ca. 2 days; Larvula stage: 4 days; 1st larval stage: days; 2nd larval stage: 3 days; 3rd (last) larval stage: ca. 12 days. The pupae hatched ter 1 day. The lifetime of the imago was 3 days.

*Abridged English translation of the *Report of the Laboratory for Inland Fisheries* No. 6.

PRELIMINARY REPORT OF STUDIES ON TRANSPORTATION OF LIVE RAINBOW TROUT

by

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and

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ABSTRACT

Physiological and biochemical factors affecting the transportation of live rainbo trout have been studied and it was found that both faeces and urine of the fi tend to increase mortality.

A decrease in mortality during transportation may be achieved by removing the excretions and by lowering the water temperature and adding oxygen.

OBSERVATIONS ON THE OCCURRENCE, COLLECTION, ACCLIMATISATION, TRANS AND SURVIVAL OF MULLET SEED IN WEST BENGAL (INDIA).

by

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ABSTRACT

Fry of several species of Grey mullets are available in coastal and estuarine are in Bengal. Mullet culture is an important industry in embanked brackishwater areas a develops during the period of reclamation of the land for rice cultivation. Stocking is eith by the natural influx of fry where the embanked areas are flooded at high tide or by t planting of fry collection in small nets in inundated areas. In the Hooghly River, t best catches of fry occur during the spring ebb tides and appear to be associated wi lunar phases.

The season of greatest occurrence of the fry are listed and a key to a detail description of the fry of *M. corsula*, *M. tade*, *M. parsia*, *M. cephalus* and *M. cunnesi* are given. The adaptability of mullet fry to differing salinities is discussed and exp iments in the transfer of fry from salt to freshwater are described. It is concluded th such acclimatization is a simple problem and does not require a long conditioning perio Comments on temperature, tolerance, artificial feeding and methods of transportation a included.

THE FISH CULTURE RESEARCH STATION (BATU BERENDAM, MALACCA, FEDERATION OF MALAYA)

by

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ABSTRACT

This Station has been established to meet a demand for additional scientific :a concerning the factors influencing the yield of fish from artificially controlled ponds. ıch work on these lines has been and is being done in many countries and a considerable ly of data on the problem of increasing production is already in existence. The problem, wever, is a formidable one and the world demand for food, especially protein food, nances not only present importance of the rearing and propagation of fish for human ısumption but also the desirability of expanding this form of farming in many tropical ıntries. Her Majesty's Government in the United Kingdom were therefore advised ıt a research station, designed specifically to examine problems associated with fish ming, was warranted. Accordingly, a sum of approximately 2·5 million dollars (Malayan) s made available from the Colonial Development and Welfare Fund for this project. e site, covering 162 acres, now carries 166 ponds varying in size from 0.025 to 4.5 :es, including 36 ponds each of 1 acre arranged as a "Latin Square" to facilitate the tistical analysis of results.

Three small open-sided field laboratories are situated in the pond area and a narrow ıge railway track facilitates the movement of foodstuffs, fertilizer and fish tanks.

Adequate laboratory and administration facilities are provided in modern single-storey ildings which include provision for a darkroom, stores, workshop, etc.

The initial investigation will be concerned mainly with the effects of inorganic tilizers upon fish yield, particularly the use of calcium, potassium, magnesium, phosphate d sulphate.

Later, studies on the genetics of cultured fish and selective breeding experiments will undertaken.

COASTAL AND HIGHLAND FRESHWATER FISHERY PROBLEMS OF PAPUA AND GUINEA

by

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ABSTRACT

The conditions of fresh water coastal and highland fisheries are described and e methods being used to develop fisheries discussed with regard to the terrain, aptitude the local people for fish culture, and how pond management may be fitted into their anging customs. Reference is made to some problems of mosquito control. The endemic sh water fishes are briefly discussed and the more important aquatic vegetation and its ssible application to pond culture techniques considered. Results of preliminary tests the introduction of *Tilapia* in ponds from sea level to 6,700 feet altitude are given.

AGE DETERMINATION OF ALBACORE BY THE VERTEBRAL METHOD

by

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ABSTRACT

An attempt was made to determine the age of central North Pacific and Hawaiian acore, *Germo alalunga* (Bonnaterre), by counting rings in the vertebral centra, a method which some degree of success had been reported elsewhere. Results were negative use of the impossibility of duplicating counts in successive readings or by different lers. It is concluded that the Albacore from these areas cannot be aged by the vertebral hod with presently existing techniques.

INTRODUCTION

This is a preliminary report on a study rmine the age and growth of Albacore, *alalunga* (Bonnaterre), taken from the of the Hawaiian Islands and from the Pacific Ocean north and northwest of . This study is part of the Albacore h program presently being conducted Pacific Oceanic Fishery Investigations of the U.S. Fish and Wildlife Service Public Laws 329 (80th Congress) and altonstall-Kennedy Act, 82nd Congress). Several workers in the past have reported age and growth of Albacore as determined xamination of the surface marking on the al centra. Aikawa and Kato (1938) based tudies on 10 large Albacore taken near y Islands and five small fish taken off astern Japan. Partlo (1955) made a more hensive study based on vertebrae of h taken during the 1950 fishing season ie offshore waters of California, Oregon, ngton, and British Columbia. Figueras followed with a brief report based on cimens taken off the coast of Galicia western Spain). Uno (1936a, b), without details of his technique, reported on sults of his study based on about a nd fish taken off the Japanese coast.

All of these workers either directly or tly suggested the presence of rings on ner surfaces of the two hollow cones amphicoelous Albacore vertebra. They ded that each ring represented an annulus herefore, the number of rings was an or of age. By measuring the distance he centre of the centrum to each ring, elieved they were deriving an estimate of the growth of the fish. Aikawa and Kato, Figueras, and Uno, as far as we can determine, have provided no evidence showing that the rings on the vertebrae are indeed "age rings" and annual in nature. Partlo hypothesized that the rings are true year marks by the following: (1) by assuming that the length groups in the size frequencies are age groups, he found that there was acceptable agreement between the mean length of fish assigned to each vertebral ring-class and the mean length of corresponding length-groups in the sample, and (2) there was agreement between the lengths of young fish calculated from vertebral measurements of older fish and the observed lengths of young fish. For the latter, Partlo, working with a subsample of 98 fish, found that the observed lengths were consistently greater than the calculated lengths because the fish were captured some time after the last ring was formed. Partlo concluded that "from the above it seems clear that the third and subseguent vertebral rings are produced annually. It is assumed, in the absence of contrary evidence, that the inner two rings are annual also."

In our study we attempted to evaluate the use of vertebrae to determine the age of Albacore taken in the North Pacific and in Hawaiian waters. Employing a wider size range of fish than had hitherto been used by any single worker, we hoped to extend previous findings to include the large fish landed in the Hawaiian Islands, and at the same time make a careful examination of the evidence appearing to indicate that the rings on the centra are true year marks. However, as will be shown, we were not able to duplicate or verify past risults, nor did we find that we could use the vertebrae to age central North Pacific and

Hawaiian Albacore. The results of our study, though largely negative, be presented for the infomation of those who are presently engaged in similar studies and for others who may work on this problem in the future.

MATERIALS AND METHODS

While most of the past investigators used thoracic vertebrae for Albacore age determination, we selected the 15th and 16th caudal vertebrae. Our choice of the caudal vertebrae was based chiefly on accessibility, or the ease with which they could be acquired in the field or at the local fish markets. Furthermore, correspondence with other investigators engaged in similar studies indicated that caudal vertebrae showed as much promise as any other. Subsequent examination of each of the 38 vertebrae of an Albacore revealed no notable differences in the appearance of the concentric markings.

Our sample, collected between January 1955 and July 1956, consisted of vertebrae from 212 Hawaiian and 53 central North Pacific Albacore. The Hawaiian Albacore, taken by the longline fishery, were generally large, ranging in size from 93 to 128 cm. (33 to 93 pounds), while the central North Pacific albacore, taken by trolling, gill net, and longline, were smaller, ranging between 51 and 112 cm. (6 to 65 pounds).

The vertebrae were sectioned and prepared for examination according to the method described by Partlo. The cleaned and dried vertebra wss cut longitudinally along the dorsoventral plane, but to one side of the mediam line, into two unequal parts. The larger of the two parts was then sanded down until the centre of the centrum was exposed. Additional cleaning and accentuating of the concentric rings were done by immersing the vertebrae in a one-percent solution of potassium hydroxide for 48 hours; this was followed by preservation in 95-percent alcohol.

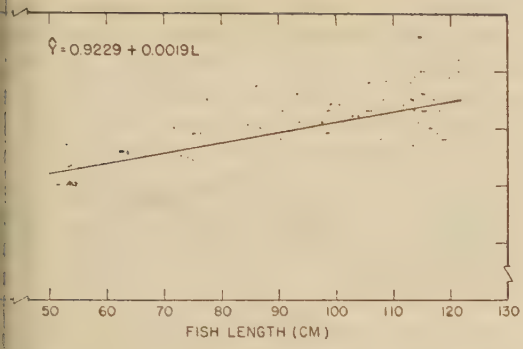
The Albacore vertebra is amphicoelous, or concave at both ends of the centrum. A sectioned vertebra reveals two cones whose vertices meet at or near the centre of the centrum with the bases forming the margins of the vertebra. On the inner surface of these cones are concentric rings running parallel to the outer margin of the centrum. These rings were described by Partlo as "narrow translucent zones separated by broad opaque zones similar to those described by Freidenfelt (192 *Lucioperca*. In the Albacore the narrow were observed not only as translucent but also as eruptions or ridges on the c surface. The innermost ring differed s from the others but was nevertheless marked." In the course of our study we that certain rings do appear as definite on the suface, while others appear as r translucent bands without any surface er and still others are more suggestions o or bands, In addition to examining t tebrae under natural and incandescent we experimented with polarized and v coloured lights but without achievin appreciable improvement in the appear the rings. Various types of stains were but here again the results were disappo from the standpoint of improving the bility" of the rings.

CHANGE IN SHAPE OF VERTEBRAE GROWTH OF FISH

In the course of examining a wide of vertebrae, we observed that while t cones of a caudal vertebra are nearly th size in small fish, the posterior cone ap larger than the anterior among large dicating that the vertebra changes its with growth of the fish. The lengths two cones were measured and the ratio two measurements was plotted against of the fish (Fig. 1) While the ratio is 1: 1 in the smallest vertebrae examine of around 50 to 60 cm. in length), the p cone is definitely larger than the ante the larger vertebrae. This changing pro is described by the rectilinear regression

$$\hat{Y} = 0.9229 + 0.0019\ L$$

where $\hat{Y}$ is the ratio of the two con L is the fork length in centimeters. Al the two cones of a caudal vertebra gro proportionately, each cone in itself exh linear growth with growth of the fish. in working with a wide size range of vertebrae, it is important that any measur of ring or vertebral radii to estimate increments of the fish should be c to either the anterior or the posterio and not to averages of the two.



ig. 1 Ratio of the average length of the or and anterior cones plotted against fish demonstrate the disproportionate growth two cones of the amphicoelous vertebrae acore.

EADIBILITY OF VERTEBRAL RINGS

fter deciding upon the criteria to be follow- authors started on a series of indepen- ing counts and ring-radii measurements. l of nine series of counts and measure- resulted in agreements between any ries of as low as eight percent and only h as 45 percent. There was poor agree- not only between counts of the two s but also between counts made by the persom. Consistency was often not achi- ven between counts of the anterior and ior cones of the same vertebra. While most disagreement was by one ring (31 to 50 nt), discrepancies of as many as four rings ed in many of the comparisons. Thus, nd that we could not satisfactorily dup- ring counts and therefore could not meet st prerequisite to the use of vertebrae ing Albacore. Our findings are in contrast tlo's, who reported that "counts of rings reproducible with high consistency."

We observed that much of the inconsis- in the counts could be attributed to the lty of distinguishing rings near the ver- the cone and also at the margain. This ot mean, however, that the rings on the l portion of the cones were clear and distinguishable, because here also many nstencies resulted.

SAMPLES FROM SMALL FISH

Age determination by means of hard parts frequently becomes more difficult and the method often breaks down completely in older fish. Since other investigators dealt largely with small fish, we concentrated our efforts on a group of similarly small fish (less than 90 cm.) in order to determine whether or not our difficulties were due to the use of larger, older fish. In one test consisting of two series of counts, we found that there was a 56 per cent agreement for fish less than 90 centimetres as compared with 30 per cent for those of larger size. The higher agreement with smaller fish is, of course, to be expected because of the fewer growth rings involved. After several more tests with series of small fish, we concluded that the counts were still far too variable to be acceptable as indicators of age.

DISCUSSION

A serious problem, especially in working with samples of small vertebrae, is to be strictly objective in making ring counts or measurements. Since there is a linear relationship between the vertebral radius and the body length of Albacore, it is almost impossible to make a reading without first forming an opinion as to how many rings a certain-sized vertebra should have. Because of the great variability in the appearance of the rings, we found it difficult to follow the criteria which we had established for judging the vertebrae. In retrospect, it may perhaps be said that our main difficulty was not so much in not being able to follow any set of criteria as not being able to develop acceptable criteria because of the variability of the rings. However stated subjectivity was inadvertently introduced into our readings, particularly when we attempted to duplicate previous findings. This can be illusrrated with an example: If the investigator measures the radius of the second ring at 5 mm. in a particular vertebra, and if all previous second-ring radii have fallen between 3 and 4 mm., he inadvertently looks closer at the vertebra for a second ring which he may have "missed". More often then not he will "find" the "missing" ring. In fact, we could locate "rings" almost anywhere on the centrum if we looked closely enough. While we could eliminate bias to alarge degree when making counts. it was much more difficult to do so in the case of measurements.

CONCLUSIONS

Although vertebrae of small Albacore were somewhat more "readable" than those of the larger Albacore, we were unable to achieve sufficient consistency in our readings and measurements to validate this method of age determination. It appears that the Hawaiian Islands and central North Pacific Albacore cannot be aged by the vertebral method with presently existing techniques.

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A REVIEW ON AGE DETERMINATION OF THE PACIFIC TUNAS

by

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ABSTRACT

Previous works on growth and age of five species of the Pacific tunas have n reviewed. Estimated growth curves of each species are found to differ to some ent. Problems expected to be inherent in age determination of the tunas are discussed the basis of studies on the spawning behaviour of the species and on the growth of other es, for which methods of age determination have been established.

INTRODUCTION

Estimation of age and growth of fish is the most fundamental works in biological s of the population. For the migratory sorting to the tropic zone, however elabo- in this subject is still required as the work mmenced rather recently. The aim of the t author is therefore to provide a survey o-date literature on age determination of ajor species of tunas* in the Pacific waters ted through examination of the size com- n and/or the hard tissues. Although there eral papers** on the items which have not vailable yet, an attempt at compiling an picture of information obtained so far ntribute toward advancement of works in ld of fishery biology.

In accordance with the decision of the ssion of the Indo-Pacific Fisheries Council) in Tokyo in October 1955, this report en prepared at the request of Mr. Z. Nakai, Biologist of the Marine Resources Section, Regional Fisheries Research Laboratory, panese member of the Sea Fisheries Panel, Thanks are due to many persons who the author in this study. Mr. H. Yabe, Biologist of the Oceanic Resources Section, Nankai Regional Fisheries Research Laboratory, Messrs. Y. Yabuta and M. Yukinawa of the same Laboratory, Dr. Y. Hiyama and Mr. Y. Nose of the Fisheries Department, Tokyo University, gave the author the conveniences to read their un-published works. Kind advice was given by Mr. A. Suda of the Nankai Laboratory, who read through the manuscript. The figures in the report were prepared by Messrs. K. Kondo, T. Kusakabe and H. Suzuki of the Marine Resources Section of the Tokai Laboratory. Mr. M. Ishida of the same laboratory helped in the preparation of the English manuscript.

WORK ON BLUEFIN TUNA

Kishinouye (1923), reporting on the commercial landings of fish in Japan, described rapid growth of tunnies to the effect that most of small individuals of the Common tunny, *Thunnus orientalis* (Synonymn for *Thunnus thynus)*, found in August and September, measure around 22 cm., some being 30 cm. or more in total length, growing to a length of 60 cm. by next spring; when two years old they are about one metre in length, eleven kg. in weight; three-year old fish most probably reach maturity, weighing about fifteen kg.

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names of the species considered here are as follows:

Scientific name	*Japanese name*	*English name*
ording to Fraser-Brunner, 1950.)		
unnus thynnus (Linne)	Kuromaguro	Bluefin tuna
. alalunga (Bonnaterre)	Binnaga	Albacore
arathunnus obesus (Lowe)	Mebachi	Bigeye tuna
eothunnus albacora (Lowe)	Kihada	Yellowfin tuna
atsuwonus pelamis (Linne)	Katsuo	Skipjack

port published from the prefectural agencies of Japan or presented in the *Commercial Fisheries Review* *Fish and Wildlife Service* could not be covered because of the limited time allocated for sent study.

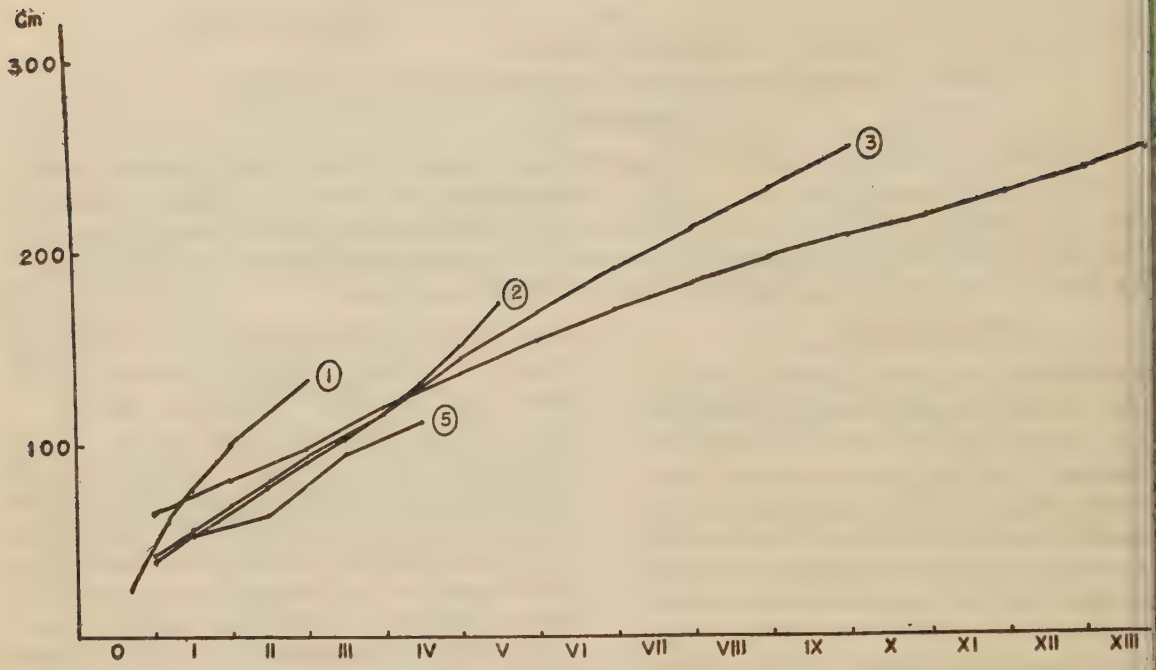


Figure 1. Growth curves in length of Bluefin tuna:
1. Kishinouye (1923); total length.
2. Kimura (1932); body length.
3. Aikawa and Kato (1938); body leng
4. Sella (1930); fork length.
5. Westman and Noville (1942); total

Studying body weight composition of the catch from the Suruga Bay in 1924 through 1931, Kimura (1932) pointed out several modes. The growth was traced on the basis of the model weight being indicative of age groups, with the growth rate increasing in summer months.

Aikawa and Kato (1938) examined the inner surface of five centra from the 7th to 12th vertebrae to determine age of the tuna landed at Ito and Tokyo. The technique, measuring the rings along their radius from the centre of the centrum cut longitudinally, was the same as that used for the mackerel by Aikawa (1937 a). According to him, the centra of mackerel show numerous rings, some of which are often different from the others in thickness and density, either complete or incomplete in formation. Nevertheless, he indicated that the representative annual rings could be distinguished from the others with their greater thickness and complete formation.

Eight years prior to Aikawa and Sella (1930) had determined the age of th in the Mediterranean by the use of the parent and opaque zones alternately ly the inner surface of vertebral centra. Wl detailed description was given of the tre of the bones in these publications, Galtsoff proposed the use of alizarin stain for det the marks.

Westman and Gilbert (1941) and We and Neville (1942) employed length comp in the study of the Atlantic Bluefin. Age fish was also determined from the scales were removed from the body under the dorsal fin and were the most suitable f examination.

WORK ON THE ALBACORE

According to Kishinouye (1923 Albacore grows at a rate similar to that Bluefin for the first two years of life. (1936) examined the vertebral centra specimens from pole-and-line catches eastern waters off Japan during May and

Although no clear-cut mode was observed
g the length and weight compositions of
er 1,500 specimens examined on this occa-
the age composition derived from the size
encies with aid of the centra examination
d with that of the above 300 specimens.
ving the vertebral centra of 688 fish cap-
in June 1936, the same author (1937) found
eans of the lengths and weights by age
arable with the results from the samples in
revious year.

Dealing with several specimens from the
eastern waters off Japan in 1937 and from
djacent waters of the Midway Islands in
Aikawa and Kato (1938) estimated the age
growth of the species on the basis of five
a from the 5th to the 10th vertebrae, accor-
to the method developed for the mackerel
ra, 1937 a). The lengths and weights for
V- and VI-age groups were found coincident
those reported by Uno (1936 and 1937).

Brock (1943) investigated length composi-
of the landings at California and Oregon, as
as examined data from the catches in
aiian, Mid-Pacific and Japanese waters.
major interest was in the former two areas,
which two modes, located between 64 and
n. and between 74 and 81 cm. respectively,
found to correspond to different age groups,
exual difference in modal lengths having
affirmed.

In the work by Nakamura, Kamimura and
ta (1953) samples of Albacore examined for
th composition comprised 39,357 individuals
e available from the longline catches during
periods of southward migration, November
to March 1949 and October 1949 to March
, in the Pacific waters north of 26°N,
een 130°E and 170°W. The composition
ed the length range larger than that of the
-and-line catch reported by Uno (1936 and
), indicating six obvious modes at nearly
tant intervals which corresponded to the
al increments estimated by Aikawa and
(1938). But the number of fish in the
al groups differed remarkably from year to
. The assumptions offered in explaining
constant modal lengths and the fluctuation
ne amount in each group were: a) annual
rence in growth, b) annual difference in
itment, and c) annual difference in pattern
igration.

Suda (1954) continued the length composition study of the southward migrants on the basis of 106,714 specimens mostly obtained from the landings at Tokyo. The samples were caught in the North Pacific waters between the Subtropical Convergence and the Polar Front, during five winters of 1948-49 through 1952-53, each season lasting from November to February. Again six modes were found. Each of them was fitted to a normal curve without any contrary evidence. However, the number of fish belonging to each modal group varied markedly season by season at 2-year intervals. Taking the two most abundant groups with the modal lengths around 78 and 89 cm., for instance, the group smaller in size was abundant in the years of 1948, 1950 and 1952, and another in 1949 and 1951. Sexual difference of the modal lengths was not apparent. If each mode was assumed to correspond to each age group, the 2nd, 3rd and 4th modes were probably IV-, V- and VI- ages segregated by Uno (1936 and 1937). But the annual increments estimated from the data were about 2 cm. larger than those by Aikawa and Kato (1938).

Suda (1955) applied the above analytical method of the composition to data based on 102,366 Albacore sampled from pole-and-line catches in the fishing grounds between 140°E and 160°E in four seasons of 1951 through 1954, each extending from May to July, the season of northward migration of the species. Though the lengths were confined to rather a narrow range between 50 and 100 cm., the modal lengths fluctuated noticeably from season to season. This seasonal difference was obviously distinct from that of the southward migrants. From the monthly composition, the growth was inferred to be more rapid in the summer season than in winter.

For the Albacore in the Eastern Pacific areas Partlo (1955) examined the age and growth with specimens collected during the 1949, 1950 and 1951 fishing seasons in British Columbia. From the length data from 78,146 specimens, at least four groups were detected by the use of probability paper for the catch in the same area and period, in which differences between samples did not appear to be appreciable. The stability of the modal lengths and fluctuations in the relative numbers of each group were obvious with the Albacore in the Eastern Pacific, as

well. At the same time, he examined the vertebral centra of 531 fish captured during the 1950 fishing season. The ninth prehaemal vertebra was selected for study because of its accessibility, uniformity of shape, and legibility of the concentric rings of the centrum. The length data of these specimens were segregated into normal frequencies by the use of probability paper. Each vertebra was longitudinally sectioned into two unequal segments. The larger segment was ground and immersed in KOH solution to accentuate the narrow, translucent rings, and eruptive bands on the inner surface of the centrum. The innermost ring is slightly different from the others but still clearly marked. Counting and measuring these rings Partlo concluded that the 3rd through 6th rings were true year marks for the following two reasons:

(1) The mean lengths of fish with 3, 4, 5 and 6 rings agreed respectively with those of the four groups that appeared in the length frequency.

(2) Lengths at the time of ring formation calculated from the vertebral radius measurements closely agreed with length-classes observed in the catch.

In the absence of contrary evidence, the two inner rings were assumed to be annuli, too. The mean length of each age class segregated like this closely agreed with that of one year younger class of the Western Pacific Albacore examined by Aikawa and Kato (1938). Partlo suggested that the Japanese workers probably did not recognize, nor accept as an annulus, the first ring measured in his study. But this problem has not been settled yet as no evidence was available.

Kawasaki and Aizawa (1955) found three modes among the fork length frequencies of the Albacore landed at six Pacific ports of Japan in 1953. The modal lengths were all in good agreement with lengths of IV-to VI-ages by the previous authors (Uno, 1936 and 1937; A and Kato, 1938), and two smaller modes c with lengths of V-and VI-ages by (1955).

Heldt (1951) reported that an A Albacore, 80.5 cm. in total length, in two annual rings on the scales, but the rate differed greatly from that estimated Gall (1950) on the basis of the length fre of 1,027 individuals.

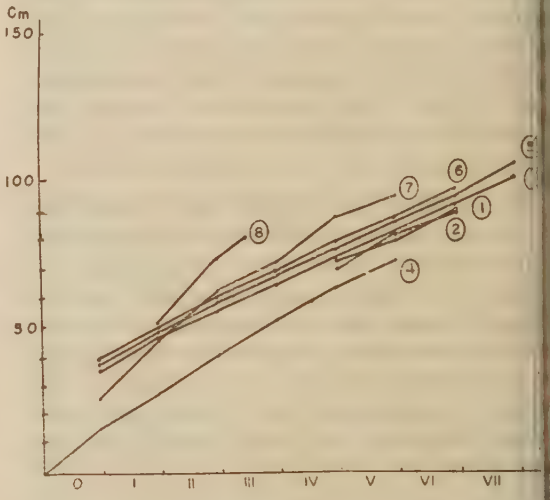


Figure 2. Growth curves in length of Albaco
1. Uno (1936) ; fork length.
2. —— (1937) ; fork length.
3. Aikawa and Kato (1938) ; body len
4. Partlo (1955) ; fork length.
5. Nose and Hiyama (in Press) ; fork l
6. —————— (in Press) ; fork
7. Le Gall (1950) ; total length.
8. Heldt (1951); total length.

Scales of the Pacific Albacore we amined by Nose, Tomomatsu, Mimu Hiyama (1955), who collected ten or scales per fish from the caudal peduncle the 4th-6th finlets because the scales fro region were thin enough to show the ring clearly. The scales were mounted dry be two glass slides. The year rings were o as transparent lines, the neighbouring ri

were closely arranged and/or interrupted. h the mean distances between the outer- ing and the scale margin did not indicate ut seasonal fluctuation, the proportion of h with a maximum marginal distance was according to their analysis of the data, to remely high in the summer and winter. is seasonal fluctuation, they stated, did m to indicate double rings that had formed a year, because the proportion of the fish maximum marginal increment was always aller than unity, and because the mean s of the fish segregated by respective rs of ridges agreed with those by the us workers (Uno, 1936 and 1937; Aikawa ato, 1938). Instead, they interpreted their ens to be broods differing in ring tion period. On the basis of the scale gs, Nose and Hiyama (in press) sed the growth trend of the Albacore.

WORK ON THE BIGEYE TUNA

As little attention has been paid so far to owth of the Bigeye tuna, only a few re- are available on the growth curves of the s. Dealing with 8,353 specimens of Bigeye rovided from the same survey as for the ore, Nakamura, Kamimura and Yabuta) found several modal groups, indicating l fluctuation in the abundance of each in the Western Pacific. The assumptions sed for explaining the varied size composi- f the Albacore-annual differences in growth, tment, or migration pattern—were also or the case of the Bigeye tuna. Conti- the study, Kamimura and Honma (1953) igated the length frequency based on 5 specimens fished in the north Pacific s upto 26°N, between 130°E and 165°W, g three winter seasons of 1950-51 through 53, each extending from October to n. The authors observed that modes of the n frequencies were nearly constant for the es from different sea areas in the same n, that the smaller fish were abundant in estern areas and the larger in the east, and he numbers of fish in the modal groups ated at 2-year intervals. It was most ble that the annual fluctuation of modal groups was ascribable to annual differences in the recruitment. On this assumption, the authors tried to draw a growth trend of the species. However, they said, it was also reasonable to assume that the differences in the modal groups were caused by annual differences in the migratory pattern.

When Honma and Kamimura (1955) examined the size frequency of the young fish taken by pole-and-line in the waters north of 26°N, between 135°E and 160°E in June and July 1953, there appeared two modal groups, lengths of which were around 55 cm. and 76 cm., respectively, the mean length of each group being smaller in the west areas than in the east. Iversen (1955) studied weight composition of the catch by the Hawaiian and Japanese longline fishermen in 1948 through 1952. The regional differences in size in this case were also found similar to those shown by Kamimura and Honma (1953). The males achieved an average size larger than the females. The noticeable differences in the positions of dominant modes were recognized between adjacent years. From these findings, the author estimated growth rate of the fish.

Studying scales of the Bigeye tuna with the method applied to the Albacore, Nose and others (1955) stated that though the time of ring formation may differ from one group to another, the ring thus formed might be regarded as an annulus for the same reasons mentioned for the Albacore-the proportion of fish with a maximum marginal increment being always much smaller than unity, and the mean length of each ring group agreeing with modal position shown by the previous workers (Kamimura and Honma, 1953). Examining the scales, Nose and Hiyama (in press) present a growth curve of the fish up to V-year olds.

WORK ON THE YELLOWFIN TUNA

According to Kishinouye (1923), the growth rate of the Yellowfin in the early two years of life is the same as that for the Bluefin. Kimura (1932) was able to determine the growth up to VI years on the basis of weight frequencies of the catch in the Suruga Bay. In the work of Aikawa and Kato (1938), the age of the Yel-

lowfin was determined by the use of the vertebral centra with the method developed for the mackerel (Aikawa, 1937a). Schaefer (1948), examining the length composition of the catch in the late winter and spring months of 1947 from the Pacific waters adjacent to the Central America, wrote that the 60 cm. fish probably were one year old, and the 85 cm. a year older. On the basis of length and weight data from 4,793 specimens of the Yellowfin caught by longline and by pole-and-line operating in Hawaiian waters during 1948 and 1949, Moore (1951) estimated the growth rate of fish from I to V years.

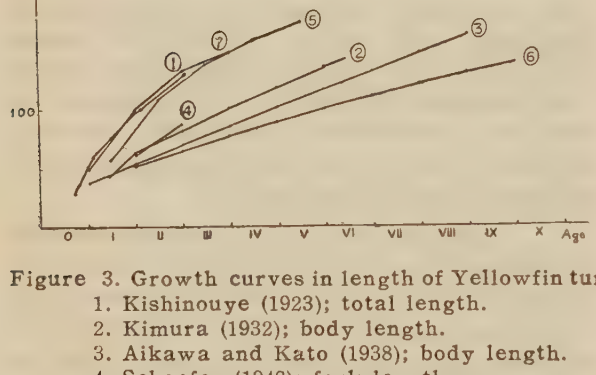


Figure 3. Growth curves in length of Yellowfin tuna.
1. Kishinouye (1923); total length.
2. Kimura (1932); body length.
3. Aikawa and Kato (1938); body length.
4. Schaefer (1948); fork length.
5. Moore (1951); fork length.
6. Nose and Hiyama (in press); fork length.
7. Yabuta and Yukinawa (in press); fork length.

Under instructions of Hiyama, Kusaka and Nose (1953), 19 students examined 50 scales of the Yellowfin, 174 scales of four other species, the herring, *Clupea pallasi* C. & V., the saury, *Cololabis saira* (Brevoort), the Common goby, *Acanthogobius flavimanus* (T. & S.), the Crucian carp, *Carassius auratus* (Linne), and 43 otoliths of the Japanese sole, *Microstomus kitaharae* Jordan & Starks. For the students, the tuna rings appeared to be more easily discernible than those of the Crucian carp but not so easily as those of the four other fishes.

The mathematical method to ded formation period of scale rings develo Nose and other (1955) was applied in the to the present species as well as the tw species of the Pacific tunas. Though t portion of the fish with a maximum m increment had peaks in May and Janu rings were conjectured to by annuli, a existence of groups differing in the ring tion period was suggested, because th were proportionally far lower than uni because the mean lengths by ring grou comparable with those by age group by vious workers (Kimura, 1932; Aikawa an 1938). The growth curve of the Yello Nose and Hiyama (in press) is by inferen the scale rings.

Iversen (1956) analysed the size f cies of 10,798 specimens from the H waters during 1950 through 1953, and specimens from the equatorial Pacific during 1951 through 1954. The monthl size shifted at an equal rate for the eq data. The Hawaiian fish, however, gre rapidly in the summer months than in the While estimates agreed in general w growth rate described by Moore (1951), growth-period between June and reported by the latter author was not r to be real.

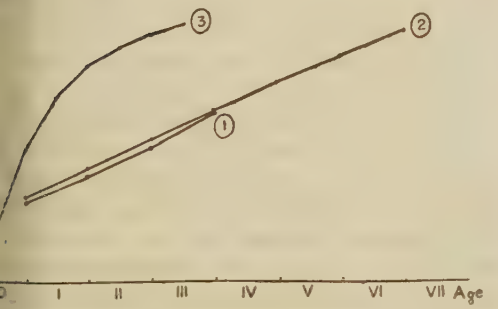
Investigating length frequencies catch from the south and east waters of in 1953 through 1955, Yabuta and Yu (in press) obtained a growth curve sim those estimated by Kishinouye (1923) Moore (1951).

WORK ON THE SKIPJACK

Among the Skipjack captured waters adjacent to Japan during 1928 1930, Uda (1932) suggested the exist two groups differing in size and habita and Tukusi (1934) could separate th landings further into three categorie (over 3.75 kg. in weight), medium (1.88 and 3.75 kg.) and small (less th kg.), the medium-sized fish being domi the northeastern waters, while the lar small were abundant in the south of Ja

Aikawa (1937 b) estimated the age of the ck from the Japanese waters up to IV by the use of vertebral centra, according echnique developed for the mackerel. Of le-and-line catch from the Ryukyu area the medium-sized fish were scarce, the ants were III-and IV-year groups, while eat majority of the catch in the northeast n were III-year and medium in size. The a number of very large Skipjack from the nt waters of Palau Island was also deter- by the vertebral centra by Aikawa and 1938).

Among weight frequencies of the catch he northeastern waters of Japan in 1939, oto (1940) pointed out four groups; the of two of them seemed to the present to be very obscure. The growth trends other two were traced for the period from une to late October. Kawasaki (1952) igated the size composition of the pole- ne catch fished in the waters northeast of during the years 1948 to 1950. The ncy of the dominant group, as large year fish assigned by Aikawa (1937b), ted two modes, the lengths of which were d 52 and 48 cm. in August, respectively. two groups significantly differed in the ion coefficient and in the habitat, the r being coastal shoals and the latter re ones.



gure 4. Growth curves in length of Skip- jack.
1. Aikawa (1937b); body length.
2. Aikawa and Kato (1938); body length.
3. Brock (1954); fork length.

Brock (1954), investigating the length composition of 30,827 specimens from the Hawaiian waters in a period during September 1946 through July 1950 drew the growth curve for the fish up to 42 months old. From the length composition of the Skipjack caught in the southwest of Japan in 1951 through 1953 Kawasaki (1955a) concluded that:

There were two groups differing in size, one being the sedentary fish around the Ryukyu Islands, and another the northward migrand. The former chiefly consisted of III-and IV-year and the latter II-and III-year fish, segregated according to the previous works (Aikawa, 1937b, Aikawa and Kato, 1938). Growth of the old roupg slackened during the spawning season of summer, while the young fish grew rapidly in that season when they migrated near to the Goto Islands in pursuit of food.

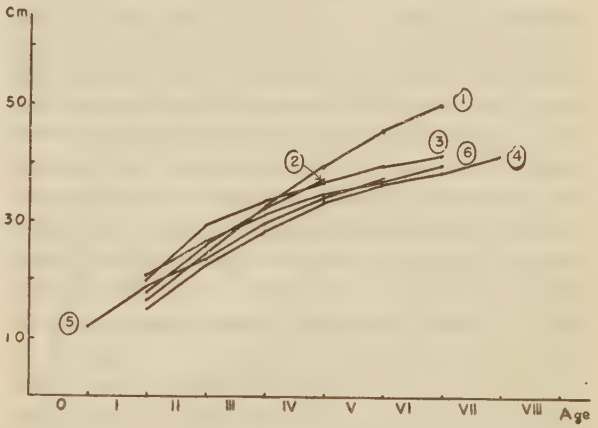


Figure 5. Growth curves in length of Japanese Mackerel.
1. Aikawa (1937a); body length.
2. Ouchi (1954); fork length.
3. Okaji (1955); fork length.
4. Yonemori and Aikawa (1955); fork length.
5. Yoshida (1955); fork length.
6. Yoshihara (1955); fork length.

The 1951-through 1953-catch from the adjacent waters of Japan were also surveyed by Kawasaki (1955b). The catch from the northeast off Honshu was chiefly composed of II-and III-year fish, and that from the vicinity of Izu and Bonin Island, of III-and IV-year, again according to the previous age determination. The growth rate in the summer months varied depending upon size of fish in the waters neighbouring Japan as well as those in the Ryukyu area.

DISCUSSION AND CONCLUSION

As an approach to the validity of age determination, the growth curves presented by the above authors have been graphically compared for each species except the Bigeye tuna* (Fig. 1-4). The mean weights of the Bluefin and Yellowfin tunas shown by Kimura (1932) were converted to the mean body lengths on the basis of condition co-efficient estimated by Aikawa and Kato. No adjustment has been made in the length which was either fork or total length for a few cases where it was not specified. However, this disregard would not seriously affect the present study, because the difference between these two measurements would probably be less than 10% of the fork length (Le Gall, 1950).

For each species, remarkable differences observed in the estimates of the growth rates were criticised by some of the previous workers. Of the Bluefin and Yellowfin tunas, Aikawa and Kato (1938) stated that the estimates based on the weight frequencies (Kimura, 1932) were found to be comparable with their results from the vertebral centra examination for ages up to the III-year old, but were too large for the older ones. On the other hand, Tauti (1940), examining the size composition of the Bluefin catch in the Suruga Bay, had a query why no fish as large as the V-year old assigned by Aikawa and Kato, were caught for five years from 1924 to 1928. Though his criticism based on the commercial catch from a single fishing ground may not be sufficient reason to reject the age determinations, recent works in Japan have provided a growth curve of the Bluefin tuna that is similar to that for fish up to II-year old obtained by Kishincuye (1923) and to the Yellowfin up to III-year old by Yabuta and Yukinawa (in press), both indicating by far a larger growth rate than those shown by Kimura and by Aikawa and Kato.

Annual unvarying growth increments of the Albacore, around 10 cm. in fork length, have been accepted by many workers but Heldt (1951). However, that unvarying rate has been criticized by many workers as indicated Discussion on the first vertebral annulus species has already been quoted from Pa

Only a few growth curves were for the Skipjack in spite of many w size composition of the commercial catc growth rate based on the vertebral rings Japanese fish (Aikawa, 1937b; Aikawa an 1938) are much smaller than that based size composition analysis of the Hawaiia (Brock, 1955). Investigating the catch f northeastern waters of Japan in 1951, (1955) stated that the growth incremen a three-or four-month period inferred fr composition seemed to be comparable w annual gain reported by Aikawa and by and Kato. But his findings may not mean unreliability of the use of vertebra because no contrary evidence was found age determination by the bones in many tical studies of the size composition landings at Japan.

Another criticism on some of p age studies was directed to the "consta of growth in length throughout the life". (1951) wrote that the unvarying rate of of the Atlantic Bluefin tuna (Sella, 1930 be ascribed to disregard of sex in the tr of data. But it is thought that the sexu rences in size or life span may not be as to preclude the drawing of a growth Moore (1951) said that the growth cu weight) of the Bluefin and Yellowfin t by some Japanese workers (Kimura, and Kato) showed no semblance of a p inflection, while his curve for the H Yellowfin indicated an inflection point terms of length and weight. Suda (19 amining the length composition of the A is inclined to think that the six modes at equal intervals do not necessarily re different age groups. If the intervals cor to annual increments, he wrote, the would grow at an approximately equ until they attained the maximum size, p lying between 120 and 125 cm. in fork following a trend very different from other organisms, the growth of which ha

* Only Nose and Hiyama (in press) have drawn a growth curve for this species, as no relatic between age and size was presented by Iversen (1955) in estimating the annual increment.

hed. In addition, there are some facts to a rejection of the previous estimate unvarying growth rate. For example, workers dealing with the Japanese el, *Scomber japonicus* Houttuyn, indicate ing of the growth rate with advance of ig. 5) compared with previous work ing a nearly constant growth rate for the uchi, 1954; Okaji, 1955; Yonemori and a, 1955; Yoshida, 1955; Yoshihara, 1955).

The present author has obtained no data gest a valid reason for the disagreements nated growth rates. Nevertheless, basing rmation on the behaviour of the species discussion and on the growth trends of the ages of which have been reliably ined, he presents an idea in an attempt ance studies in the age determination of as.

Growth studies of the tunas were chiefly on the size frequency analyses of the rcial catch. To apply this method, how- t has to be provided that the spawning lace within a certain season of the year at the fishing operation is carried out in tire range of distribution of fish larger certain size. Except for the problem of election, the last condition may be fairly d for the catch in the recent years, when hing boats with improved methods and nent have operated over a wide range. ver, extensive seasons and grounds for ing were found for most species of the tunas (e.g. see Marr, 1948; Nakamura, Schaefer and Marr, 1948). In addition a s accepted in the size of the Bigeye tuna e Skipjack, seemingly in the same age s (Honma and Kamimura, 1955; Iversen, Kamimura and Honma, 1953; Kawasaki, . These facts require, in size frequency es of the commercial catches, information e fishing gear, season and areas as well re extensive knowledge on the spawning ours, growth and migration of the juve-

Ages of most species of fishes inhabiting mperate and frigid zones have been deter- by the use of hard tissues including bones, and otoliths. While some workers have ned also these tissues of tunas for age determination, it should be kept in mind that there are remarkable differences in the spawning behaviour and seasonal fluctuation of environmental conditions between the tunas and the fishes in temperate and frigid zones. As for the latter species, the environmental conditions, e.g. temperature and food, fluctuate considerably from season to season, and the spawning takes place within a particular season of the year. The obvious seasonal fluctuation of physiological conditions has been regarded one of the causes of ring formation on the tissues. However, most of the tunas spawn nearly throughout the year in the tropical or subtropical seas, and the immature fish migrate to the temperate zone in the summer months seeking food, while the mature fish stay in the spawning seas in which seasonal fluctuation of the environment is not appreciable. Differences in migratory routes depending on age or on size is especially clear for the Skipjack (Kawasaki, 1955a and b) and the Albacore (Suda, 1956). When the age of fish is to be determined by the use of hard tissues, it is recommended that a large number of samples comprising the fish differing in age or size as well as from different fishing grounds should be examined to establish ring formation period, a subject which has not been studied by anyworker except Nose and others (1955).

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A NOTE ON THE DIFFERENCE OF THE BASIC ORGANIC PRODUCTION BETWEEN THE SEAS OF LOW AND HIGH LATITUDES

by
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ABSTRACT

Some criticisms of the accepted notion of the basic organic production in erent latitudes of the sea have been reviewed on the basis of published works. The idea gested by Riley (1939) that there is little or no difference between the basic organic duction in low and high latitudes, may be true as long as problems in limited areas are cerned. However, this may not be applicable to the standing crop in the sea in general. view of results of more recent works, the author would like to emphasize that the anic production of the sea must be understood exactly in order to exploit effectively the eries resources.

THE GROWTH AND AGE OF YELLOWFIN TUNA

by
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ABSTRACT

The studies on the growth and age of Yellowfin tuna were reported by Kimura 932), Aikawa, Kato (1938), Walford (1946), and Moor (1951), but there are many diffe- nces in their results.

The authors studied the size composition of the Yellowfin tuna caught by pole-and-line d longline in Japanese waters, and the following information were obtained on the growth d age of the species:

1. *The data and the sea area:*

The data were collected by the examination of Yellowfin tuna landed at Tokyo, Yaizu d Katsuura fish markets. In Japanese waters, Yellowfin tuna is caught by pole-and-line in mmer, and by longline in winter. Waters north of 20° N and west of Ogasawara islands the main fishing grounds.

2. *Yellowfin tuna caught by pole-and-line:*

The length frequency data show one or two length groups, which are similar each ar. In the groups N—1 and N—2, transitions of modes, which are thought to be caused by e growth, are noticed.

It is not clear whether the N—2', N—3' groups occurred formerly as N—2, N—3 oups in Japanese waters or arise from different spawnings. Further investigations by tag- ng, spawning and differences between year groups are required.

3. *Yellowfin tuna caught by longline:*

These length frequencies show two or three length groups. Transitions of modes, esumably due to growth, are recognized. From September to October, the abundance of the 0 cm. group diminishes.

4. *Growth and age:*

It is thought that the larger Yellowfin caught by pole-and-line and the smaller fish ught by the longline belong to the same length group.

It is considered that the transition of the modes of each group shows the growth groups which have an age difference of one year.

It is thought that the curves (A-F) show the growth of fish groups which have differences of one year. Assuming that the group with a mode at 50 cm. fork length is age, then the range of length by age would be:

0 + age			50 cm.
I	50	—	100 „
II	100	—	135 „
III	135	—	145 „

but further data is required for III age-group, the percentage of which is small, and the tion of the mode is not clear.

5. *Comparison with previous reports:*

The rate of growth reported by the authors is faster than that estimated by Kin (1932), Aikawa and Kato (1938) and coincides with that obtained by Walford (1946) and M (1951) from the examination of Yellowfin tuna in Hawaiian waters. It is thought that the of growth coincides with that of Yellowfin tuna in the waters of the West Carolines, and the growth of Yellowfin tuna is very rapid.

The report is to be published in full in the *Report of Nankai Regional Fisheries Lab tory* No. 5.

FISHING GEAR RESEARCH

by
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INTRODUCTION

Traditionally fishing gear and methods been mainly evolved by trial and error fishermen and while some aspects of net g and the development of accessory ment have long been carried out in a sional manner, the designing of fishing s still an art rather than a craft.

During the last decade or so certain ls and instruments have, however, been ped for testing the properties of fishing naterials and assessing their suitability ecific fishing purposes; the performance ing gear can now also be studied and lled under actual fishing conditions. In some of the tools and methods of rational esearch are already in existence although echnology has yet to be established as a ized profession.

) ACTIVITIES IN GEAR TECHNOLOGY

Among FAO's activities aimed at sti- ing gear technology work the following l be mentioned:

nnotated Bibliography on Fishing Gear lethods is now ready in manuscript form e hope it will be published later this year. g the past few years we have regularly ed more than 200 fisheries journals to t and condense material suitable for our *fisheries Abstracts*. We have also tried to ll old and new fisheries publications which come to our notice. In the course of this we have collected over 3,000 bibliographic nces on fishing gear and out of those we now selected about 500 titles of which we made brief annotations, meant to give an as to the useful technical information ined.

ndbook on Fishing Gear and Methods is paration and will give *detailed descriptions pecifications of advanced types of commer- important fishing gear and their mode of tion.* We hope to have this book ready for publication in 1958, and it should be a valuable reference work for all fisheries workers concerned with improving local gear or in introducing new methods of fishing.

International Fishing Gear Congress. It will be recalled that in 1953, FAO organized the International Fishing Boat Congress which brought together for the first time naval architects, boat builders, engine manufacturers and government officials in charge of fishing boat development from many countries. The results of this Congress have been published in a 600-page volume entitled *Fishing Boats of the World,* which has been widely acclaimed as an outstanding reference work on existing knowledge of fishing boat design and construction.

A need for a similar Congress on Fishing Gear has long been felt by those working with experimental fishing, fishing gear design, gear research, etc. A major problem in organizing such a Congress is, of course, to select an appropriate agenda and as the Congress will be limited in duration to one week, it is proposed to concentrate the papers and discussion on *recent developments in gear materials, rational design of fishing gear, mechanical handling of gear, fish/gear/ship relationship and attraction and detection of fish* as outlined in the draft agenda appended hereto (See Appendix).

It will be seen that the agenda for the Congress has aimed at getting papers concerned with modern types of commercial gear, gear materials and accessory equipment and focusses attention on recent development of proved practical value. The exchange of knowledge and experience of experts from all parts of the world will be of great value in helping to extend the use of modern, effective equipment and practices to those parts of the world where they are unknown or little known at present. So far over 120 papers have been announced, of which about 40 are from the Indo-Pacific Region, mostly from Japan.

The Congress will take place in Hamburg between 7-12 October 1957. It is open to all those who are concerned with fishing and a large participation from makers of fishing gear and accessory equipment, research workers, fishing vessel owners and leading fishing skippers as well as Government officials concerned with fisheries development is assured. The strong and widespread interest in the Congress which is already evident, points to the fact that such a Congress will fulfill an urgent need and it is to be hoped that representatives of the greatest possible number of countries in the Indo-Pacific Region will be able to attend despite the high cost of travel to Europe.

GOVERNMENTAL ACTIVITY IN GEAR TECHNOLOGY

In most of the countries of the Indo-Pacific Region the fisheries are just beginning to develop from their age-old traditional stage and although some fisheries departments now have plans which call for rapid development of fishing gear and craft they generally lack the facilities and trained personnel for carrying out any rational gear research. It, therefore, appears evident that more governmental activity will be required in this field, parallel to the institutions now concerned with fisheries biology and fish processing in most fishing countries.

While in Japan there are several gear research laboratories staffed with well-trained gear technologists, no such institutions exist in other countries in the Indo-Pacific Region. The Government of India has, however, decided to establish a gear research laboratory and FAO has provided, through the Technical Assistance Programme, a Japanese gear technologist, Dr. H. Miyamoto, to assist in organizing and establishing such a Laboratory. Dr. Miyamoto has now concluded his initial field survey of fishing centres in the various coastal states of India in preparation for establishing the laboratory which will be situated in Cochin.

There is certainly a great scope for such institutions in other countries in the region to carry out work in the following fields:

1) Testing of material, both locally made and imported; endeavouring to improve locally made fishing yarns (for instance by correct stranding and twisting, pre-treatment, etc.) a vising importers and the fish dustry on the proper select materials to suit particular purposes.

2) Treatment and preservation of nets; testing the suitability of available and imported preser and advising the industry on t per care and treatment of equipment.

3) Testing the efficiency of local gear and methods by experi and comparative fishing; endeav to improve their effectiveness troducing such foreign equipm practices as might prove e under local conditions; modifyi gear as needed and demonstrat proper use to local fishermen.

4) Collaborating with Governme ing boat development statio boat builders in introducing driven winches and other equ for efficient handling of the ge

5) Experimenting with and advis local industry on the proper se of suitable methods and equ for locating and detecting fish gational aids, echo-sounders) as equipment and methods for ting fish (light fishing).

Encouraging results of fishing made by private industry, Fisheries Depa staffs and Technical Assistance experts i that capital investment in fishing equipm bound to increase rapidly in the near throughout the Indo-Pacific Region — form of synthetic fibre nets and mech fishing units involving the use of compl expensive accessory equipment. This ment must be protected and at the sam the standard of living of the fishermen n improved. It is, therefore, increasing portant to make full use of existing kno in an organized manner and it is one of duties to assist member countries to es such gear technological centres as dis here.

APPENDIX

INTERNATIONAL FISHING GEAR CONGRESS 1957

SUBJECTS PROPOSED FOR THE AGENDA

INTRODUCTION

The purpose of this Congress is to sise the recent developments in fishing not to describe traditional types of gear have long been sued in fishing in various ies. The Congress therefore is concerned he latest types of commercially important nd with current thought and experiment ned with improving existing fishing gear ccessory equipment, manufacturing it economically, making it more efficient and ing it more effectively. In view of these lerations, the proposed agenda for the ess has been drawn up under seven main gs as follows:

MATERIALS

The early difficulties in the use of nylon, s knot slippage, have now been largely me and the former high prices have come to a more competitive level. This is not realized in some countries, nor is the g industry everywhere fully informed of velopment and rapidly increasing use of synthetic fibres such as Terylene, Dacron, and Vinylon and mixtures of these s fibres. At the same time, research is forward in an effort to improve the gth and durability of the natural fibres. It erefore, proposed that papers summing up rogress achieved in the various parts of rorld be submitted to the Congress and ssed, covering the following points:

1.1 Terminology and Numbering Systems

Some confusion seems to arise from differing use of such terms as "fibre", "thread", "yarn", "twine", "twist", etc. The many different numbering systems used by the various manufacturers of man-made net yarns also cause a great deal of confusion. A well defined basic reference is needed (perhaps the "denier" system?), or at least a universal conversion table.

1.2 Comparison of characteristics

Physical, chemical and biological characteristics of the materials used in modern net making and the methods employed for testing their: Strength, wet, dry; with or without knots; elasticity, shrinkage, abrasive strength, weight/length, water absorption, softness, visibility, resistance against chemicals, thermal resistance, slippage in knots, processed fibres (natural, "converted", cotton, etc.), ease of handling, durability, and first cost.

1.3 Preservation and maintenance of gear made of different materials

Here the discussion would centre around preparation of the gear before use as well as preservation and maintenance during its use and while in storage to provide protection against the chief biological, chemical and mechanical agencies of gear destruction and the methods available for testing the efficiency of such treatment. Included here should be treatment of the gear which aims at improving its catchability such as colouring, changing weight or stiffness etc.; preparation or pre-treatment, periodic preservation and maintenance, testing efficiency of treatment.

1.4 Relative efficiencies of gear made of different materials

Under this heading would be discussed the many comparative fishing experiments with gear of natural and synthetic materials.

2. RATIONAL DESIGN OF FISHING GEAR

This should certainly be one of the major subjects discussed at the Congress. Although rational Gear Technology is yet to be established as a recognized profession, certain methods and

tools of the trade have been evolved in various parts of the world. By bringing together the existing knowledge in this field, the Congress will contribute towards progress in applying rational working methods in the design of fishing gear. The papers would deal with:

2.1 The use of physical and engineering theory and experiments with models.

2.2 The use of measuring instruments and direct observation under water of the behaviour of gear and the reaction of fish to gear.

2.3 The use of available data on the selectivity of fishing gear, (such as mesh size), in relation to the efficiency of the gear for catching the species and sizes of fish desired.

2.4 Comparative fishing experiments.

2.5 Methods of specifying shape, dimensions, quality and other characteristics of fishing gear.

3. RATIONAL CONSTRUCTION OF NETS

The rising cost of manual labour in all parts of the world makes it imperative to mechanize the knitting of webbing wherever possible and to simplify the construction of nets from machine-made webbing.

3.1 Mechanical knitting of nets

There is need for greater interchange of information among those concerned with mechanical net knitting, especially in finding ways and means of overcoming the difficulties encountered when working with synthetic fibres. One interesting development is "knotless nets" which are coming into use in Japan. Papers would deal with the relative merits and suitability, for different fibres and different types of nets, of bonded twines / thermoset twines/single knot/double knot, special knots, knot tightening, and knotless nets.

3.2 Cutting and tailoring of webbing

The cutting of machine-made webbing and "tailoring" according to drawings and diagrams, simplification and standardization (use of standard types and sizes and standard spare sectio save labour in the manufacture ensure that the equipment will as ordered, or in other words, m a standard of quality; last but no to simplify and save work in tenance.

4. OPERATION OF FISHING GEAR

In the same way as the rational ap can be applied to the design of fishing can also be applied to a greater extent present in the choice and operation of t in order to achieve higher efficiency an costs. The "fishing" operation is not co until the catch is landed. The handling catch influences and is influenced by the and operation of the fishing gear, deck equ and layout of the vessel and should, th be considered here, but only in relatio effect on the gear and its handling.

4.1 Choice of fishing gear

Both type and details, as dete in relation to the fish, vessel, weather, sea, crew, human fact economic circumstances. Sel of gear (mesh size, etc.) is of one important factor to be disc but only in relation to profitable tion—not conservation, which is outside the scope of this Congr

4.2 Efficient handling of fishing ge

Labour-saving, power-handlin machinery, remote control, au release and overload mech instruments for measuring the tions under which the gear wo recording and controlling its mance, layout and features of v

4.3 Efficiency in handling the catc

Indication of catch size, h process, treatment, handli storing on board, unloading and facilities on vessels.

5. STRATEGY AND TACTICS OF FIS

The discussion under this heading centre around methods of increasing ef of fishing operations and particularly the developments in the location, detecti attraction of fish.

5.1 **Location of fish**

In the operation of the large, costly, modern boats it is increasingly important to waste the minimum of time in locating productive fishing grounds. It is therefore important to make the fullest possible use of accumulated knowledge of fishing grounds and seasons, sea temperature and currents and to make such information available in the form of fishing charts, etc.; hydrographic and biological observations (use of thermometer, current meter, plankton sampler, etc.) exchange of information during fishing by R.-T; fleet searching, and re-location of known fishing grounds by use of modern navigational aids, such as D.F., Decca, Loran, etc.

5.2 **Detection of fish**

In no other field of fisheries has there been so rapid and significant development as in electronic devices for detecting fish. Echo-sounders are available in several basic types, i.e., as spark indicators, paper recorders or cathode-ray tubes; of low, medium and high frequencies; shallow or deep range, focusing on large or small segments of the depth, etc. Echo-ranging equipment is offered in various forms. A discussion of these characteristics in relation to their applicability to specific fishing purposes might provide useful guidance in selecting the proper type of equipment to suit particular fishing conditions; aerial scouting; echo-sounding (vertical); echo-sounding (horizontal); and future prospects (acoustic, T.V. camera ?).

5.3 **Attraction of fish**

The reactions of fish to stimuli (sight, taste, smell, sound) are basic considerations in most methods of fishing. In many cases, effective techniques are practised in some regions but are unknown or neglected in others. For instance, the attraction of fish by light could probably be used more widely in conjunction with conventional gear and perhaps also with pumping, electrical fields, etc. Refinements in the use of this and other stimuli might provide an interesting subject for discussion, centering on use of light, lures, bait, chemical attractants, and other methods.

6. ELECTRICAL FISHING

While electrical fishing is used to some extent in fresh water, serious problems have been met in applying this technique to salt water fishing. From time to time, optimistic reports circulate about advances made, but evidence substantiating them is scarce, It would therefore be useful to give, at the Congress, a factual account of present day knowledge of electrical fishing. This would clarify the situation, dispel illusions and perhaps make possible a reasonable assessment of the prospects in the near future.

7. FUTURE DEVELOPMENTS

When summing up, towards the end of the Congress, it might be useful and interesting to stimulate speculative discussion on the likely impact on world fishing by new or recent developments, such as the new devices for the location, detection and attraction of fish, newly developed gear and methods, (such as the wider application of mid-water trawling), increased power handling of gear, the effect of new developments in preservation and processing of the catches on board, which in turn affect the size of vessels, their range and mode of operation; factory ship operations; fleet operations with mother ships and catcher boats following a stock of fish on oceanic migration, etc.

What demands will these new developments make on general layout, size, power and special equipment of fishing vessels and on the training of fishermen?

In which fields is development lagging or particularly needed?

A NEW METHOD OF HANDLING LONGLINE GEAR

(*A Description of POFI "Tub" Gear*)

by

Herbert Mann

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ABSTRACT

Modifications to Japanese-type longline gear, by the introduction of a large, rotating from which the line is handled, have resulted in a considerable saving in manpower. nventional gear can be operated in this manner with few changes. Instead of using lividual baskets of line which must be separated and joined together for each day's ning, a continuous mainline is set from, and hauled into, a wooden storage drum. This novation is the product of continuing studies to increase the efficiency of longline gear.

INTRODUCTION

The Pacific Oceanic Fishery Investiga- (POFI) of the U.S. Fish and Wildlife e has found longlining to be an effective s of capturing tunas in the relatively bait- aters of the central Pacific. This report bes a new method of fishing longline gear tly developed at POFI following a sugges- y Mr. A.K. Akana, our fleet supervisor.

Longline gear used in the beginning of programme was copied from conventional ese designs. Experience showed that this of gear, although adequate as a sampling or exploratory fishing, required too many by American standards, to be ideally suited ommercial use. During the past several many attempts have been made to improve fficiency of the gear to a point where it t be commercially feasible for American tions. The so-called "tub" gear des- d below is the most succesful effort to in that it permits a material reduction in usual number of men required to fish ine gear.

The essence of the tub method lies in a and novel means of handling the mainline. ad of the individual baskets of conventional which must be separated and joined together for each day's fishing, tub gear has a mainline of one continuous length which is set from and hauled into the large wooden storage drum which gives this method its name. Droppers and floatlines are removed from the mainline when hauling and are reattached during setting operations.

The tub method of fishing requires only minor changes in the design of conventional longline gear. Standard POFI gear or any longline with detachable droppers and floatlines may be fished by this method by adding "D" rings (described below) to the mainline.

DESCRIPTION OF THE GEAR

POFI longline gear is of a flexible design so that the gear can be altered readily to meet the changing requirements of an exploratory fishing programme. Components are detachable and can be assembled so as to fish varying number of hooks at different depths.

Shown in Fig. 1 is a schematic representation of a single unit, or basket, of POFI gear of the lastest type. In typical POFI fishing operations from 60 to 100 such baskets are joined together to make one day's "set". Since the units are identical, only one is shown in the diagram.

Indo—Pacific Fish. Coun., 7 (II—III): 73—76, 1957.

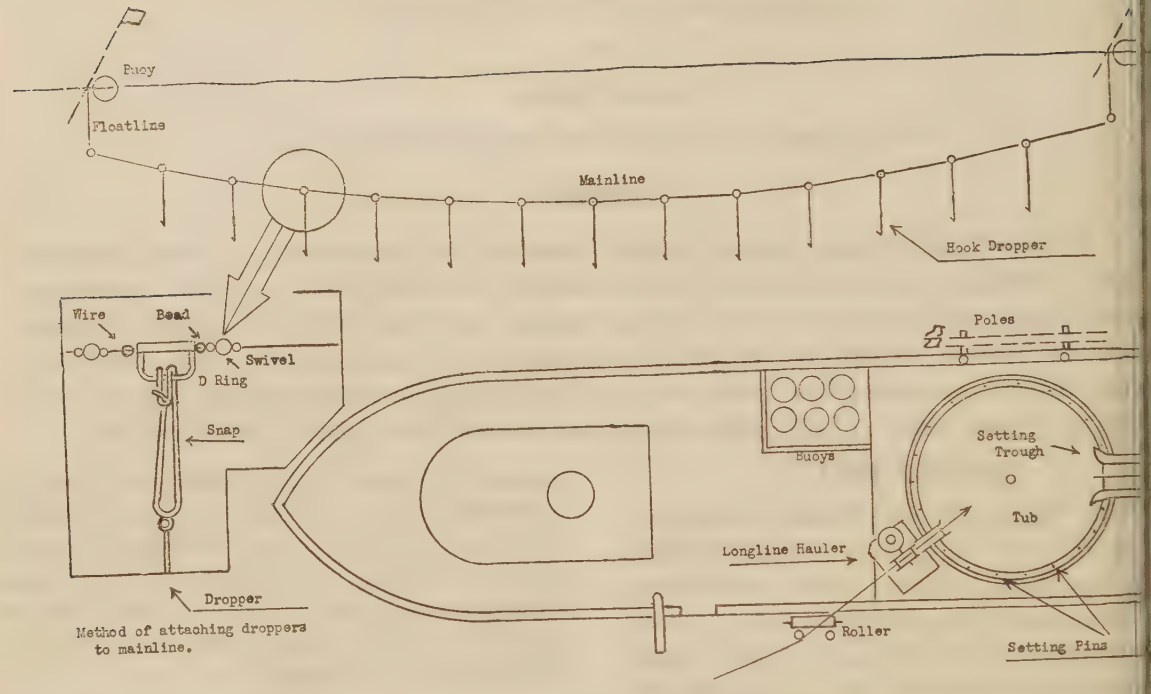

Figure 1. Schematic drawing showing the arrangement of a single unit, or "basket", of PO longline gear, and the location of the line storage tub on the stern of the vessel.

The Mainline

The mainline is made up of fourteen identical sections knotted together by double sheet bends. Each section consists of a 15-fathom length of preserved 261 thread hard-laid cotton twine with an eye splice in one end and a wire bridle, "D" ring, "pigtail" at the other. Baskets are joined by a "clover leaf" knot which is formed with an extra loop for attachment of the floatline.

Dropper Attachment

Hook droppers are attached to the mainline by the "AK" snap and "D" ring arrangement shown in Fig. 1. The "D" ring, a new addition to POFI gear, eliminates a troublesome defect of old gear. Formerly, "AK" snaps were clipped directly to a wire bridle. This type of attachment permitted the dropper to swivel around the mainline and prevented tangles of dropper and mainline when gear was being hauled aboard ship, but it sometimes failed to function properly when large fish pulled the dropper parallel to the mainline. At acute angles of pull, the snap ceased to ha swivelling action and sometimes was pul of shape or broken. The "D" ring ma proper swivelling action with the d pulled in any direction. Rings are fab from stainless steel tubing with a lower formed in a U shape and welded to th section. Rings are threaded on a wire made up of a 6-inch length of $\frac{3}{32}$-inch di 7×7 stainless steel wire rope. Wire rop holding swivels at each end of the brid made with Nicopress fittings. These of malleable copper sleeves which are p on the wire by a hand tool. Brass beads wire act as miniature thrust bearings a the swivelling action of the "D" ring. swivels relieve torque on the mainline occurs when the line is being brought in hauler.

Hook Dropper

Hook droppers are made from 2- lengths of 261 thread line. An "AK" s

into the upper end. The lower end ter-
s in an eye splice for securing leader and
Leaders are fashioned of 6-foot lengths
-inch diameter 7-strand galvanized wire.
pper end of the leader is fitted with a
i of $\frac{3}{8}$-inch rubber tubing which serves
ing gear. Hooks are 8/0 or 9/0 tinned
ie hooks of a special shape with bent
which allows the hook to hang in line
he leader.

nes

Floatlines are made from 10-fathom
s of 261 thread line. The lower end of
ine has an "AK" snap for attachment to
ainline. Snaps are clipped to loops in
ie as shown, rather than to "D" rings,
it has been found that "D" rings and
ridles do not hold up under the incessant
g caused by the rise and fall of floats
ea and swell.

torage Tub

Shown in Fig. 1 is a schematic drawing
wooden tub used for storage of the main-
The experimental model used aboard the
nd Wildlife vessel *John R. Manning* is a
e-walled plywood cylinder measuring 12
in diameter and 4 feet in depth. This
ity is sufficient for the storage of 100
ts of gear. For greater ease in setting, the
mounted near the stern of the vessel, but
iate space between tub and railing is left
round. The drum is supported in the
e by a heavy bearing bolted to the deck;
uter edge runs on cast iron rollers of the
used to support the turntable of a purse
ig vessel. Reinforcing bands of 3-inch
metal are welded around the outside of
ib for extra support. Thirty-three stainless
setting pins are spaced at equal inter-
nside the tub.

The gear is hauled by means of a long-
which of conventional Japanese design.
rically powered by a 3 h.p. motor, such a
h brings line in at a maximum rate of about
feet per minute and coils it down automa-
y with only slight assistance from the
h operator. The hauler is mounted so that
ne is thrown just over the edge of the tub.

The setting trough is a demountable sheet metal form used to guide the outgoing mainline during the setting operation. In general design it is similar to that used in the Northwest Pacific halibut fishery.

OPERATION OF THE GEAR

Preparation for Cruise

Prior to sailing on a fishing cruise, baskets of mainline are knotted together and fed through the Japanese line hauler into the tub. No attempt is made to coil the line down uniformly into regular piles, but it is deflected by hand so that it is evenly distributed in thickness over the bottom of the tub. As the "D" rings pass through the hauler, they are caught and threaded upon the setting pin nearest the hauler. All fourteen rings of one basket are placed upon the same pin and the knot marking the end of the basket is looped on top. The tub is then turned by hand until the next setting pin comes in line with the winch. To avoid piling up the line, the baskets are spaced on every other pin; when the tub has completed one revolution, a second and finally a third layer of line is laid over the first so that 99 baskets are held on 33 setting pins. The tub is covered with a canvas tarpaulin to prevent the line from being displaced in rough weather.

Setting

When setting, the tub is rotated by hand until the uppermost basket comes under the setting trough. The vessel steers a steady course and proceeds at a speed of up to 9 knots. The buoy and floatline, marking the end of the set, are attached to the mainline, which in turn is led through the trough, and the assembly is thrown overboard. Thereafter the drag of the end basket pulls the mainline overboardas the vessel proceeds.

Hooks are baited with sardines, *Sardinops caerulea* (Girard), or herring, *Clupea pallasii* (Valenciennes). Individual hook droppers are attached to the mainline by clipping the "AK" snap at the upper end of the dropper to the uppermost "D" ring. They are then laid in the setting trough one by one with the hook and bait dangling overboard. Float droppers are attached in the same manner. As the end of each basket leaves the setting pin, the tub is

turned to keep successive baskets in line with the setting trough.

Hauling

The gear is hauled through overside rollers on the starboard side of the fishing vessel. The mainline is led through the hauler and coiled into the tub. As droppers come aboard, the winch is stopped momentarily and dropper snaps are removed from the "D" rings. Hook droppers are coiled in specially built plywood boxes and are stowed with hooks exposed on one side and with snaps held by clips on the other. Fish are gaffed and brought aboard through an opening in the bulwark. The line is stowed in the tub as described before, with three baskets of "D" rings being placed upon each pin.

Broken or tangled portions of mainline are removed by unknotting the line section junctions, repaired, and joined to the end of the mainline after the fishing operations are completed. Because the sections are identical they need not be restored to their original positions.

GENERAL DISCUSSION

Tub longlining, although still in the experimental stage, already offers several advantages over conventional methods of handling gear. In particular the method seems applicable to small vessels carrying a limited number of men.

The saving in labour by using tub longlining is considerable. Since a basket of POFI gear weighs about 40 pounds when wet and a day's set may consist of up to 100 baskets, about 4,000 pounds of wet line must be broken out and restowed by hand for each day's fishing when using conventional methods. But with the POFI tub method considerable labour is saved because it eliminates all manhandling by flaking the line directly into the tub.

During experimental POFI fishing tions with tub gear, five men were suffic operate the gear as against a crew of normally required for conventional gear methods require, for each basket of line $1\frac{1}{2}$ minutes for setting and $3\frac{1}{2}$ minut hauling.

Some difficulties in operation hav experienced. The most troublesome pro date is excessive wear and tear on the m due to the "D" ring running at high through the overside rollers and longline At high hauling speeds "D" rings stri rollers or hauler with enough force to be rings or break wire bridles. Greatly nee a method of joining droppers to the main a system which permits swivelling freely direction but which offers little resista passage through the line hauler.

One difficulty which was anticipat which failed to materialize was fouling mainline during setting operations. P that the setting trough is properly design outgoing mainline runs smoothly in the trough and fouling of the mainline is les when setting by conventional methods.

Up to the present time, all POF have been rotated manually. Since this is still in the experimental stage, it h been thought necessary to install a mec means for rotating the tubs. However, method is to be used commercially, p tubs should increase efficiency.

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APPENDIX

INTERNATIONAL FISHING GEAR CONGRESS 1957

SUBJECTS PROPOSED FOR THE AGENDA

INTRODUCTION

The purpose of this Congress is to ise the recent developments in fishing ot to describe traditional types of gear have long been sued in fishing in various es. The Congress therefore is concerned ie latest types of commercially important id with current thought and experiment ned with improving existing fishing gear ccessory equipment, manufacturing it conomically, making it more efficient and ng it more effectively. In view of these erations, the proposed agenda for the ss has been drawn up under seven main gs as follows:

MATERIALS

The early difficulties in the use of nylon, s knot slippage, have now been largely me and the former high prices have come to a more competitive level. This is not realized in some countries, nor is the industry everywhere fully informed of velopment and rapidly increasing use of synthetic fibres such as Terylene, Dacron, and Vinylon and mixtures of these s fibres. At the same time, research is forward in an effort to improve the th and durability of the natural fibres. It refore, proposed that papers summing up ogress achieved in the various parts of orld be submitted to the Congress and sed, covering the following points:

1.1 Terminology and Numbering Systems

Some confusion seems to arise from differing use of such terms as "fibre", "thread", "yarn", "twine", "twist", etc. The many different numbering systems used by the various manufacturers of man-made net yarns also cause a great deal of confusion. A well defined basic reference is needed (perhaps the "denier" system?), or at least a universal conversion table.

1.2 Comparison of characteristics

Physical, chemical and biological characteristics of the materials used in modern net making and the methods employed for testing their: Strength, wet, dry; with or without knots; elasticity, shrinkage, abrasive strength, weight/length, water absorption, softness, visibility, resistance against chemicals, thermal resistance, slippage in knots, processed fibres (natural, "converted", cotton, etc.), ease of handling, durability, and first cost.

1.3 Preservation and maintenance of gear made of different materials

Here the discussion would centre around preparation of the gear before use as well as preservation and maintenance during its use and while in storage to provide protection against the chief biological, chemical and mechanical agencies of gear destruction and the methods available for testing the efficiency of such treatment. Included here should be treatment of the gear which aims at improving its catchability such as colouring, changing weight or stiffness etc.; preparation or pre-treatment, periodic preservation and maintenance, testing efficiency of treatment.

1.4 Relative efficiencies of gear made of different materials

Under this heading would be discussed the many comparative fishing experiments with gear of natural and synthetic materials.

2. RATIONAL DESIGN OF FISHING GEAR

This should certainly be one of the major subjects discussed at the Congress. Although rational Gear Technology is yet to be established as a recognized profession, certain methods and

tools of the trade have been evolved in various parts of the world. By bringing together the existing knowledge in this field, the Congress will contribute towards progress in applying rational working methods in the design of fishing gear. The papers would deal with:

2.1 The use of physical and engineering theory and experiments with models.

2.2 The use of measuring instruments and direct observation under water of the behaviour of gear and the reaction of fish to gear.

2.3 The use of available data on the selectivity of fishing gear, (such as mesh size), in relation to the efficiency of the gear for catching the species and sizes of fish desired.

2.4 Comparative fishing experiments.

2.5 Methods of specifying shape, dimensions, quality and other characteristics of fishing gear.

3. RATIONAL CONSTRUCTION OF NETS

The rising cost of manual labour in all parts of the world makes it imperative to mechanize the knitting of webbing wherever possible and to simplify the construction of nets from machine-made webbing.

3.1 Mechanical knitting of nets

There is need for greater interchange of information among those concerned with mechanical net knitting, especially in finding ways and means of overcoming the difficulties encountered when working with synthetic fibres. One interesting development is "knotless nets" which are coming into use in Japan. Papers would deal with the relative merits and suitability, for different fibres and different types of nets, of bonded twines/thermoset twines/single knot/double knot, special knots, knot tightening, and knotless nets.

3.2 Cutting and tailoring of webbing

The cutting of machine-made webbing and "tailoring" according to drawings and diagrams, simplification and standardization (use of standard types and sizes and standard spare sectio save labour in the manufacture ensure that the equipment will as ordered, or in other words, m a standard of quality; last but no to simplify and save work in tenance.

4. OPERATION OF FISHING GEAR

In the same way as the rational ap can be applied to the design of fishing can also be applied to a greater extent present in the choice and operation of th in order to achieve higher efficiency and costs. The "fishing" operation is not com until the catch is landed. The handling catch influences and is influenced by the and operation of the fishing gear, deck equ and layout of the vessel and should, the be considered here, but only in relation effect on the gear and its handling.

4.1 Choice of fishing gear

Both type and details, as dete in relation to the fish, vessel, weather, sea, crew, human fact economic circumstances. Sele of gear (mesh size, etc.) is of one important factor to be disc but only in relation to profitable tion—not conservation, which is outside the scope of this Congr

4.2 Efficient handling of fishing gea

Labour-saving, power-handlin machinery, remote control, au release and overload mecha instruments for measuring the tions under which the gear wo recording and controlling its mance, layout and features of v

4.3 Efficiency in handling the catch

Indication of catch size, h process, treatment, handlin storing on board, unloading and facilities on vessels.

5. STRATEGY AND TACTICS OF FIS

The discussion under this heading centre around methods of increasing eff of fishing operations and particularly the developments in the location, detecti attraction of fish.

5.1 **Location of fish**

In the operation of the large, costly, modern boats it is increasingly important to waste the minimum of time in locating productive fishing grounds. It is therefore important to make the fullest possible use of accumulated knowledge of fishing grounds and seasons, sea temperature and currents and to make such information available in the form of fishing charts, etc.; hydrographic and biological observations (use of thermometer, current meter, plankton sampler, etc.) exchange of information during fishing by R.-T; fleet searching, and re-location of known fishing grounds by use of modern navigational aids, such as D.F., Decca, Loran, etc.

5.2 **Detection of fish**

In no other field of fisheries has there been so rapid and significant development as in electronic devices for detecting fish. Echo-sounders are available in several basic types, i.e., as spark indicators, paper recorders or cathode-ray tubes; of low, medium and high frequencies; shallow or deep range, focusing on large or small segments of the depth, etc. Echo-ranging equipment is offered in various forms. A discussion of these characteristics in relation to their applicability to specific fishing purposes might provide useful guidance in selecting the proper type of equipment to suit particular fishing conditions; aerial scouting; echo-sounding (vertical); echo-sounding (horizontal); and future prospects (acoustic, T.V. camera ?).

5.3 **Attraction of fish**

The reactions of fish to stimuli (sight, taste, smell, sound) are basic considerations in most methods of fishing. In many cases, effective techniques are practised in some regions but are unknown or neglected in others. For instance, the attraction of fish by light could probably be used more widely in conjunction with conventional gear and perhaps also with pumping, electrical fields, etc. Refinements in the use of this and other stimuli might provide an interesting subject for discussion, centering on use of light, lures, bait, chemical attractants, and other methods.

6. ELECTRICAL FISHING

While electrical fishing is used to some extent in fresh water, serious problems have been met in applying this technique to salt water fishing. From time to time, optimistic reports circulate about advances made, but evidence substantiating them is scarce, It would therefore be useful to give, at the Congress, a factual account of present day knowledge of electrical fishing. This would clarify the situation, dispel illusions and perhaps make possible a reasonable assessment of the prospects in the near future.

7. FUTURE DEVELOPMENTS

When summing up, towards the end of the Congress, it might be useful and interesting to stimulate speculative discussion on the likely impact on world fishing by new or recent developments, such as the new devices for the location, detection and attraction of fish, newly developed gear and methods, (such as the wider application of mid-water trawling), increased power handling of gear, the effect of new developments in preservation and processing of the catches on board, which in turn affect the size of vessels, their range and mode of operation; factory ship operations; fleet operations with mother ships and catcher boats following a stock of fish on oceanic migration, etc.

What demands will these new developments make on general layout, size, power and special equipment of fishing vessels and on the training of fishermen?

In which fields is development lagging or particularly needed?

A NEW METHOD OF HANDLING LONGLINE GEAR

(*A Description of POFI "Tub" Gear*)

by

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ABSTRACT

Modifications to Japanese-type longline gear, by the introduction of a large, rotating from which the line is handled, have resulted in a considerable saving in manpower. ventional gear can be operated in this manner with few changes. Instead of using vidual baskets of line which must be separated and joined together for each day's ing, a continuous mainline is set from, and hauled into, a wooden storage drum. This ovation is the product of continuing studies to increase the efficiency of longline gear.

INTRODUCTION

The Pacific Oceanic Fishery Investiga- POFI) of the U.S. Fish and Wildlife has found longlining to be an effective of capturing tunas in the relatively bait- iters of the central Pacific. This report es a new method of fishing longline gear ly developed at POFI following a sugges- Mr. A.K. Akana, our fleet supervisor.

Longline gear used in the beginning of programme was copied from conventional se designs. Experience showed that this f gear, although adequate as a sampling r exploratory fishing, required too many y American standards, to be ideally suited mmercial use. During the past several many attempts have been made to improve ficiency of the gear to a point where it be commercially feasible for American ions. The so-called "tub" gear des- below is the most succesful effort to n that it permits a material reduction in sual number of men required to fish ne gear.

The essence of the tub method lies in a nd novel means of handling the mainline. d of the individual baskets of conventional which must be separated and joined together for each day's fishing, tub gear has a mainline of one continuous length which is set from and hauled into the large wooden storage drum which gives this method its name. Droppers and floatlines are removed from the mainline when hauling and are reattached during setting operations.

The tub method of fishing requires only minor changes in the design of conventional longline gear. Standard POFI gear or any longline with detachable droppers and floatlines may be fished by this method by adding "D" rings (described below) to the mainline.

DESCRIPTION OF THE GEAR

POFI longline gear is of a flexible design so that the gear can be altered readily to meet the changing requirements of an exploratory fishing programme. Components are detachable and can be assembled so as to fish varying number of hooks at different depths.

Shown in Fig. 1 is a schematic representation of a single unit, or basket, of POFI gear of the lastest type. In typical POFI fishing operations from 60 to 100 such baskets are joined together to make one day's "set". Since the units are identical, only one is shown in the diagram.

Indo—Pacific Fish. Coun., 7 (II—III): 73—76, 1957.

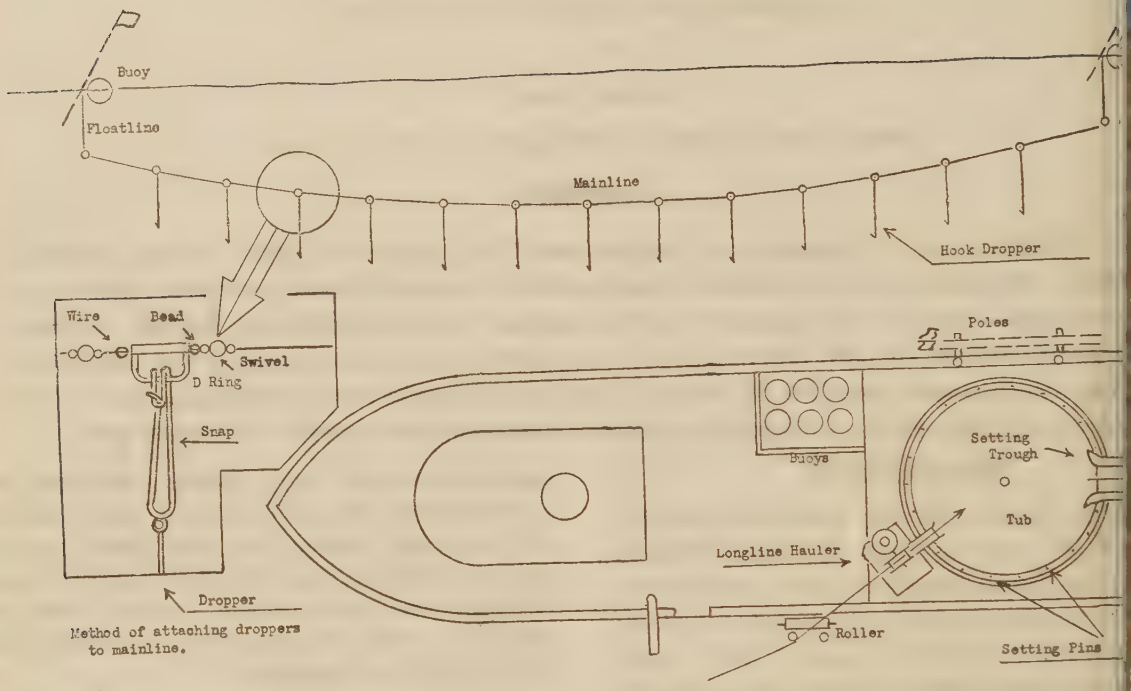

Figure 1. Schematic drawing showing the arrangement of a single unit, or "basket", of P longline gear, and the location of the line storage tub on the stern of the vessel.

The Mainline

The mainline is made up of fourteen identical sections knotted together by double sheet bends. Each section consists of a 15-fathom length of preserved 261 thread hard-laid cotton twine with an eye splice in one end and a wire bridle, "D" ring, "pigtail" at the other. Baskets are joined by a "clover leaf" knot which is formed with an extra loop for attachment of the floatline.

Dropper Attachment

Hook droppers are attached to the mainline by the "AK" snap and "D" ring arrangement shown in Fig. 1. The "D" ring, a new addition to POFI gear, eliminates a troublesome defect of old gear. Formerly, "AK" snaps were clipped directly to a wire bridle. This type of attachment permitted the dropper to swivel around the mainline and prevented tangles of dropper and mainline when gear was being hauled aboard ship, but it sometimes failed to function properly when large fish pulled the dropper parallel to the mainline. At acute angles of pull, the snap ceased to h swivelling action and sometimes was pu of shape or broken. The "D" ring m proper swivelling action with the pulled in any direction. Rings are fa from stainless steel tubing with a lower formed in a U shape and welded to t section. Rings are threaded on a wir made up of a 6-inch length of $\frac{3}{32}$-inch c 7 × 7 stainless steel wire rope. Wire ro holding swivels at each end of the br made with Nicopress fittings. These of malleable copper sleeves which are on the wire by a hand tool. Brass bead wire act as miniature thrust bearings the swivelling action of the "D" ring swivels relieve torque on the mainlin occurs when the line is being brought i hauler.

Hook Dropper

Hook droppers are made from 2 lengths of 261 thread line. An "AK"

into the upper end. The lower end ter-
s in an eye splice for securing leader and
Leaders are fashioned of 6-foot lengths
-inch diameter 7-strand galvanized wire.
per end of the leader is fitted with a
of $\frac{3}{8}$-inch rubber tubing which serves
ing gear. Hooks are 8/0 or 9/0 tinned
e hooks of a special shape with bent
which allows the hook to hang in line
ie leader.

nes

Floatlines are made from 10-fathom
s of 261 thread line. The lower end of
ne has an "AK" snap for attachment to
ainline. Snaps are clipped to loops in
e as shown, rather than to "D" rings,
it has been found that "D" rings and
ridles do not hold up under the incessant
g caused by the rise and fall of floats
ea and swell.

torage Tub

Shown in Fig. 1 is a schematic drawing
wooden tub used for storage of the main-
The experimental model used aboard the
nd Wildlife vessel *John R. Manning* is a
e-walled plywood cylinder measuring 12
n diameter and 4 feet in depth. This
ity is sufficient for the storage of 100
ts of gear. For greater ease in setting, the
mounted near the stern of the vessel, but
ate space between tub and railing is left
round. The drum is supported in the
by a heavy bearing bolted to the deck;
ter edge runs on cast iron rollers of the
used to support the turntable of a purse
g vessel. Reinforcing bands of 3-inch
metal are welded around the outside of
b for extra support. Thirty-three stainless
setting pins are spaced at equal inter-
nside the tub.

The gear is hauled by means of a long-
which of conventional Japanese design.
rically powered by a 3 h.p. motor, such a
brings line in at a maximum rate of about
feet per minute and coils it down automa-
y with only slight assistance from the
operator. The hauler is mounted so that
ne is thrown just over the edge of the tub.

The setting trough is a demountable sheet metal form used to guide the outgoing mainline during the setting operation. In general design it is similar to that used in the Northwest Pacific halibut fishery.

OPERATION OF THE GEAR

Preparation for Cruise

Prior to sailing on a fishing cruise, baskets of mainline are knotted together and fed through the Japanese line hauler into the tub. No attempt is made to coil the line down uniformly into regular piles, but it is deflected by hand so that it is evenly distributed in thickness over the bottom of the tub. As the "D" rings pass through the hauler, they are caught and threaded upon the setting pin nearest the hauler. All fourteen rings of one basket are placed upon the same pin and the knot marking the end of the basket is looped on top. The tub is then turned by hand until the next setting pin comes in line with the winch. To avoid piling up the line, the baskets are spaced on every other pin; when the tub has completed one revolution, a second and finally a third layer of line is laid over the first so that 99 baskets are held on 33 setting pins. The tub is covered with a canvas tarpaulin to prevent the line from being displaced in rough weather.

Setting

When setting, the tub is rotated by hand until the uppermost basket comes under the setting trough. The vessel steers a steady course and proceeds at a speed of up to 9 knots. The buoy and floatline, marking the end of the set, are attached to the mainline, which in turn is led through the trough, and the assembly is thrown overboard. Thereafter the drag of the end basket pulls the mainline overboardas the vessel proceeds.

Hooks are baited with sardines, *Sardinops caerulea* (Girard), or herring, *Clupea pallasii* (Valenciennes). Individual hook droppers are attached to the mainline by clipping the "AK" snap at the upper end of the dropper to the uppermost "D" ring. They are then laid in the setting trough one by one with the hook and bait dangling overboard. Float droppers are attached in the same manner. As the end of each basket leaves the setting pin, the tub is

turned to keep successive baskets in line with the setting trough.

Hauling

The gear is hauled through overside rollers on the starboard side of the fishing vessel. The mainline is led through the hauler and coiled into the tub. As droppers come aboard, the winch is stopped momentarily and dropper snaps are removed from the "D" rings. Hook droppers are coiled in specially built plywood boxes and are stowed with hooks exposed on one side and with snaps held by clips on the other. Fish are gaffed and brought aboard through an opening in the bulwark. The line is stowed in the tub as described before, with three baskets of "D" rings being placed upon each pin.

Broken or tangled portions of mainline are removed by unknotting the line section junctions, repaired, and joined to the end of the mainline after the fishing operations are completed. Because the sections are identical they need not be restored to their original positions.

GENERAL DISCUSSION

Tub longlining, although still in the experimental stage, already offers several advantages over conventional methods of handling gear. In particular the method seems applicable to small vessels carrying a limited number of men.

The saving in labour by using tub longlining is considerable. Since a basket of POFI gear weighs about 40 pounds when wet and a day's set may consist of up to 100 baskets, about 4,000 pounds of wet line must be broken out and restowed by hand for each day's fishing when using conventional methods. But with the POFI tub method considerable labour is saved because it eliminates all manhandling by flaking the line directly into the tub.

During experimental POFI fishin tions with tub gear, five men were suffi operate the gear as against a crew of normally required for conventional gea methods require, for each basket of line 1½ minutes for setting and 3½ minu hauling.

Some difficulties in operation ha experienced. The most troublesome pr date is excessive wear and tear on the r due to the "D" ring running at high through the overside rollers and longline At high hauling speeds "D" rings str rollers or hauler with enough force to b rings or break wire bridles. Greatly ne a method of joining droppers to the mai a system which permits swivelling freel direction but which offers little resist passage through the line hauler.

One difficulty which was anticipa which failed to materialize was fouling mainline during setting operations. H that the setting trough is properly desig outgoing mainline runs smoothly in the trough and fouling of the mainline is le when setting by conventional methods

Up to the present time, all PO have been rotated manually. Since this is still in the experimental stage, it been thought necessary to install a me means for rotating the tubs. However, method is to be used commercially, tubs should increase efficiency.

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'BANGOS' FRY TRAWL

by

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ABSTRACT

An appraisal of the predominant method of catching 'bangos' fry is given. The
r describes the construction and operation of the gear which he personally had designed
ied. The advantages in the use of the gear are pointed out as the following: rapidity
ase of operation; increase in the rate of catch; capability of operation even in strong
and in rough weather; easily mechanized; economical in the use of nets and
ower thus lowering the cost of the bangos fry; can be used either as a stationary
bile gear; and can be operated in shallow as well as in deep waters.

INTRODUCTION

supply the giant bangos *(Chanos*
ishpond industry of the Philippines, an
t supporting industry for the catching
s fry has developed in many coastal
ie Archipelago. This industry provides
ent to a large number of fishermen,
women and children, during the sum-
ths when the fry are in season. The
annual catch of bangos fry has been
l by Villadolid *et al* (1943), and by
ial fry dealers at around 147,000 pots or
00 fry. The principal fishing gear that
for this catch are the 'panagap' or two-
e, the 'saplad' or tidal set net, and the
or scissors net (Blanco and Villadolid,
All these types of gear use 'sinamay', a
oarse cloth woven out of 'abaca' fibre.

ie panagap is a rectangular sinamay
ut 6 metres long by 3 metres wide. It
ed by two persons along shallow sandy
here bangos fry are known to concen-
fter covering a sufficient distance, drag-
topped and the fry are dipped out with
enamelled basin.

he saplad consists of a V-shaped
with the walls or wings usually made
ied bamboos and set across the mouth
w rivers to catch bangos fry that come
tide. At the end of the wings a fine
cloth, rectangular in shape, is placed
-like where the fry are concentrated
ght. The whole contrivance is raised
as the water rises, to keep the upper
above water level.

The sakag is similar to the common scissors net used in catching 'alamang' and small shrimps.

The saplad is popularly used in the Ilocos fry grounds, while the panagap is used predominantly in southern Luzon and the Central Philippines. The relative importance of these gear is shown in the following estimate of the catch each contributes to the over-all total production; panagap, 50%; saplad, 40%; sakag10%.

APPAISAL OF EXISTING FRY GEAR

During a recent (1955) survey of the bangos fry grounds in Southern Luzon, the writer observed the operation of the prevailing methods of catching bangos fry to note their various short-comings. Although the panagap is the most widely used gear in southern Luzon especially in the provinces of Batangas, Quezon, Mindoro, Marinduque and Albay, it was found to have many defects. It is cumbersome and heavy to drag in the water and it can hardly be worked against a strong wind or in a heavy sea. To collect the captured fry, dragging has to be stopped and the whole gear has to be gathered to concentrate the catch. Much time is lost, thereby. Because the gear cannot be dragged fast enough, a large percentage of the catch is able to escape since the commercial bangos fry are already fast swimmers.

Sakag or scissors nets used for catching fry cannot be used in rough sea or in deep water.

The saplad is generally installed only in a shallow section of river mouths and it has to

o—*Pacific Fish. Coun.*, (II—III): 77—81, 1957.

be constantly adjusted to the rising tide. A large section of the river, especially if it is deep, is left open and its fry potential unexploited.

The advantage of panagap is that it can be used during both low and high water. On the other hand, the saplad, once set in a stream, requires little effort in prop volume of catch. Saplad operators, have to use the panagap when the r the rivers are blocked by sand bars.

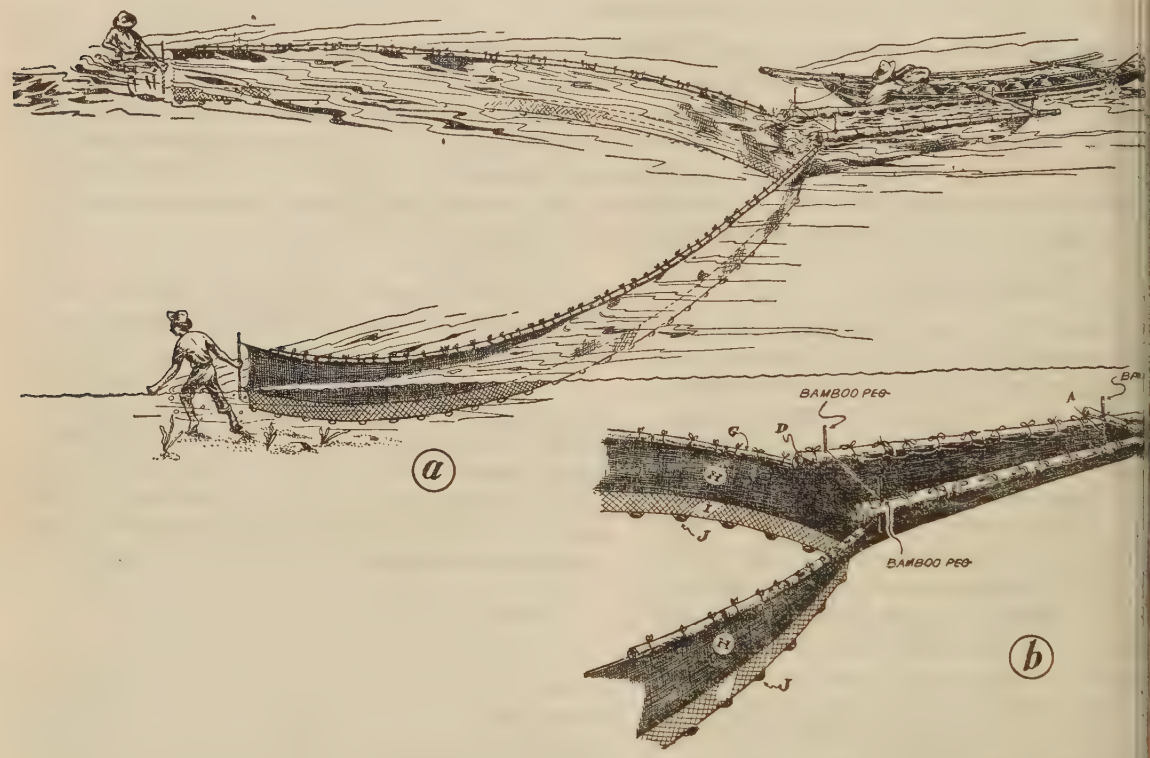

Fig. 1. Operation of the 'Bangos' fry trawl; a) Operation as a 'Panagap' (Mobile G b) Operation as a 'Saplad' (Stationary

The bangos industry at present depends almost entirely on the fry caught by panagap, saplad and sakag. Any improvement, therefore, of these nets to increase their catch would redound to the ultimate benefit of the industry. With this view, the writer designed a new gear in which he sought to eliminate the defects of the traditional bangos fry gear. The result was the development of a light and highly effective contrivance which is the subject of this paper. This new gear combines the features of a panagap and a saplan (Fig. 1). In this paper it will be called bangos fry trawl. It was first tried in the fry grounds of Tiwi, Albay Province. It is being used already by bangos fry catchers in Bulan and Gubat, Province, certain localities in Polillo Gesan, Marinduque Province. Demo have been conducted recently in th Salinas, Cavite Province.

PLAN OF THE GEAR

Figure 2 shows the plan of cons the bangos fry trawl. The plan sho carries practically all the standard fe trawl net without a top cover: a pair o small floor or belly, and a catching whole trawl is made of fine-meshe reinforced on the edges with $\frac{3}{8}$ inch al

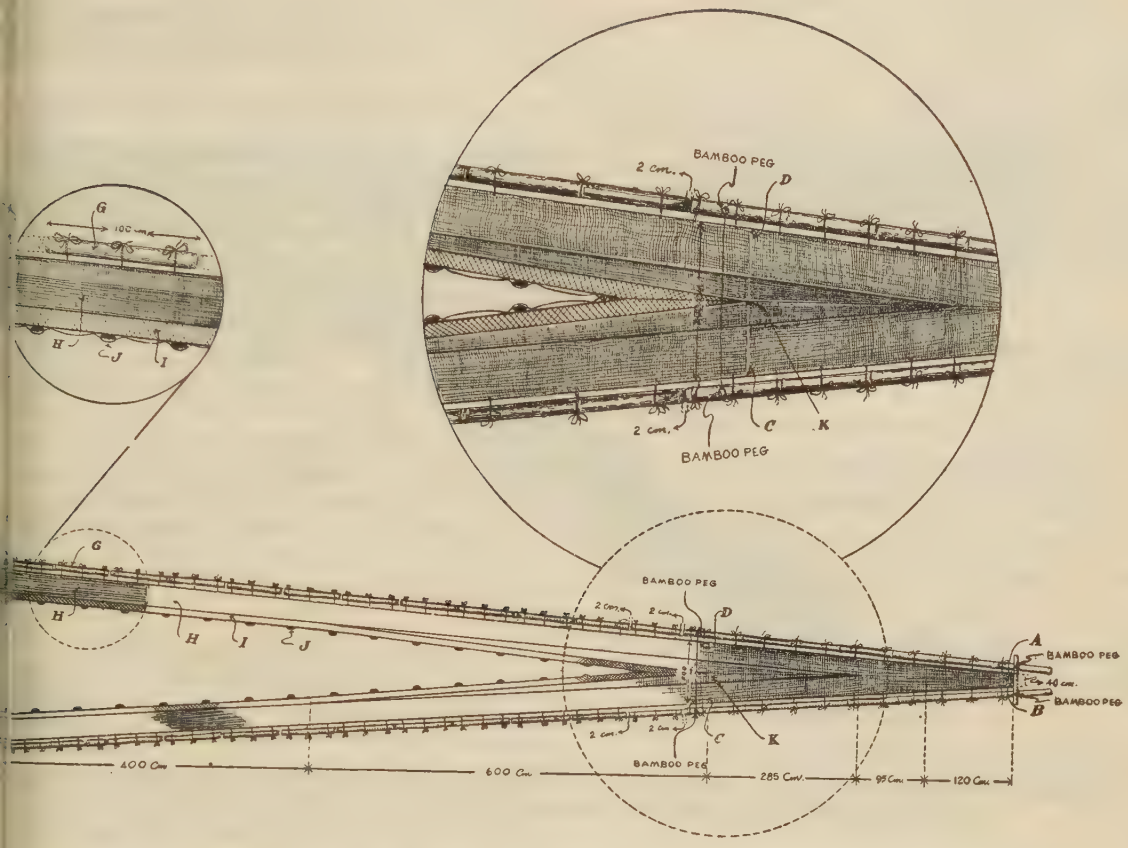

Fig. 2. Construction details of the fry trawl net.

CONSTRUCTION OF THE GEAR

the standard fry trawl the belly and end or saplad section ABCD is a lal piede 500 cm. long, 200 cm. wide at ard end and 40 cm. wide at the blind ne pair of wings, DKEF and CKEF, is s long, 95 cm. wide at the junction with and 50 cm. at the free end. The lower the two wings are provided with a (I) of abaca netting of 1 inch, 3 to 4 deep. The leadline is hung from this The abaca selvage minimizes wear of the fine-meshed and delicately-made and the accumulation of sand and n the wings and belly. Old pieces of ets of 1 to 2 inches mesh may also be

he sinamay cloth, when joined together, e sewn. The free edges are folded and reinfored with abaca rope of 3/8 inch. The rope is extended beyond the corners of the wings to serve as handles for pulling the net.

OPERATION OF THE GEAR

The bangos fry trawl, combining the features of the saplad and the panagap, can be used as either, with practically no modification.

The Gear as a Panagap

When used as a panagap the fry trawl is dragged by two persons, one at the end of each wing (Fig 1). A third man goes alongside the scooping end with a banca containing receptacles for bangos fry. As the trawl is dragged along, he keeps clearing this section of debris and dipping out the fry that accumulate at the cod-end.

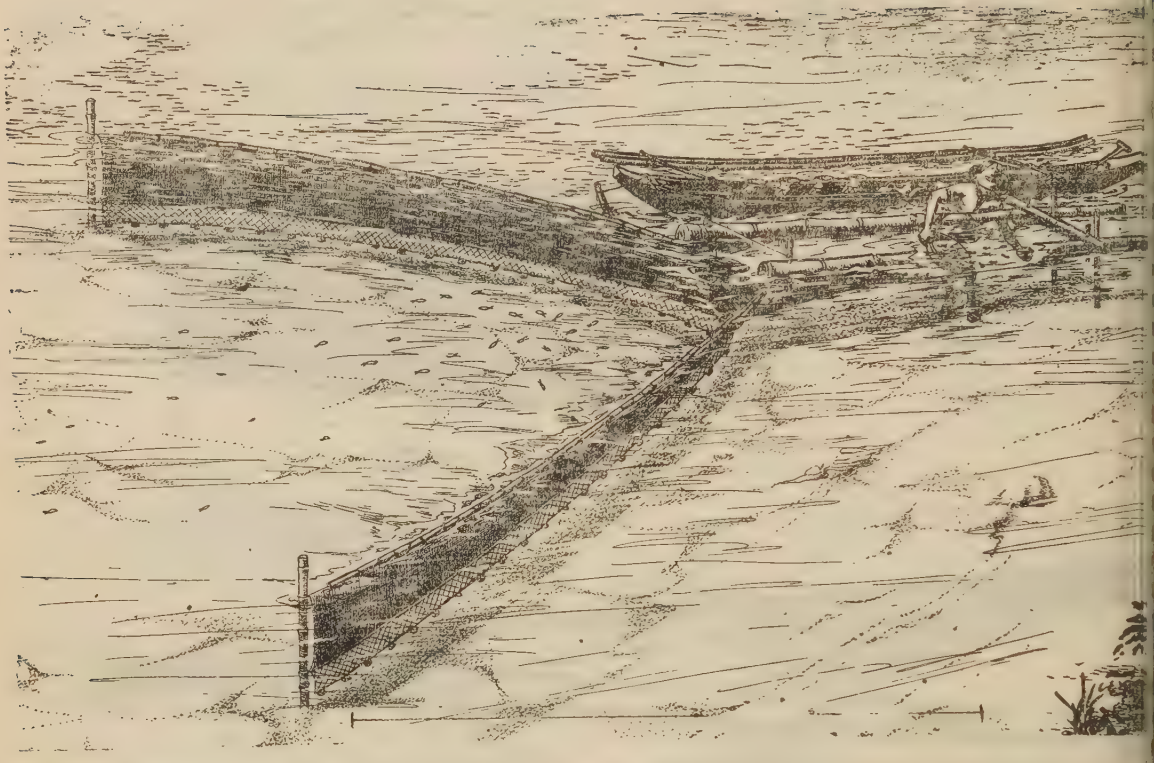

Fig. 3. Details showing the operation of the 'Bangos' fry trawl as a 'Saplad', and 'Ba fry being collected from the cod-end.

The whole trawl is kept afloat by a series of bamboo tubes fastened to the floatline. The floats for the wings (G) are pieces of bamboo one metre long and tied along the floatline, end to end with a clearance of 1 or 2 cm. The floats for the saplad section are a pair of bamboos 6 metres long and about 10—12 cm. in diameter, the larger diameter being placed toward the rear. The distance of the saplad floats at forward end may be reduced from the maximum 200 centimetres by shortening the twine that joins the two ends. It is, however, fixed at 30 to 40 centimetres at the scooping end of the net by means of a cross bamboo piece pegged to the bamboo floats at A and B. Thus transfixed, the two bamboo floats are prevented from rolling and the scooping end is kept open. The bamboo floats project about 1 metre beyond the scooping end to offset the tendency of the net to sink at this point, due to the current concentrating here.

The wings are weighed by a series of clay weights (J) about 2 inches long and 1 inch in diameter. They are hung at 30 cm. intervals on the leadline from the bel tip of the wings.

To prevent the escape of bangos saplad section the sinamay net is hung four bamboo pegs driven vertically bamboo floats.

The Gear as a Saplad

When used as a stationary gear the fry trawl is set at the mouth of with the use of four stakes: one on ea the wings and one on each corner form saplad floats and the bamboo cross piece (Fig. 2 and 3). When the tide ebbs th of the trawl is easily reversed to scree flowing water. A series of trawls c stalled to cover the entire width of the

The advantage of the trawl when as a fixed gear over the standard sapl the trawl, with its series of bamboo fl with the rising tide and *vice versa*, a automatically adjusts itself to fish at

ctive level. The trawl, therefore, catches fry from both the incoming and outgoing than the rigidly installed saplad.

AMENABILITY TO MECHANIZATION

It is now a common observation that bangos e present not only along the shore but also r out in the open sea. Catching bangos th along the shore and in the open sea may e commercially feasible with a mechanized . The fry trawl can be operated from two like a floating Spanish trawl or from a single In the latter case, the boat used is provided double out-riggers and uses a pair of nets led on each side of the boat. What is of the original trawl is the belly, the ing end, and, if the length of the out-riggers it, part of wings. The pieces of bamboo are replaced by two long bamboo poles ood with sufficient leverage to keep the h open and to adjust it to the right fishing .

Mechanical trawling for bangos fry would d be a great improvement over the panagap, adius of operation of which is limited to ng depth. This radius is further reduced g high tides when wading becomes so ult that fishing has to stop. The mechanized rawl, therefore, can fish from the shore-line y depth where bangos fry are in commercial entration.

RECAPITULATION OF ADVANTAGES OF 'BANGOS' FRY TRAWL

Based on the present application of the os fry trawl, the following have been noted e its decided advantages over the present ods:

1. It is faster and easier to operate since it offers less resistance to the water.
2. The fry are automatically concentrated at the saplad end and can be dipped out without stopping the catching operation.
3. It catches more fry per unit time, the equivalent of one trawl being about three to five conventional panagap by actual observation.
4. It can be operated in strong wind and in rough sea.
5. It lends itself easily to mechanization.
6. Because of its high efficiency, less number of nets and men are needed to operate a bangos fry concession, thus lowering the ultimate cost of bangos fry.
7. It can be used either as a stationary gear (saplad) or as a mobile gear (panagap).
8. When used as a saplad it can be easily installed in shallow as well as in deep waters.

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A PRELIMINARY REPORT ON THE SEA SCANAR, AN ULTRA-SONIC FISH FINDER

by
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ABSTRACT

A description of the Sea Scanar model 1Nl, a new dual-system, ultra-sonic fish finder used by the Pacific Oceanic Fishery Investigations, is presented. Experiments designed to test the capabilities of the instrument show that it will detect a single metal target 24" in diameter at 2,180 ft. and a skipjack weighing 20 lb. at 1,070 ft. Rough seas reduce effective range slightly. Contact with a target can easily be maintained while the ship approaches it, Traces of aggregations of skipjack, dolphin, porpoise, and blackfish were recorded.

COMPARISON OF FISHING EFFICIENCY BETWEEN A. LONGLINE AND "RAWAI" (PRAWE) B. TRAWL AND "DOGOL" C. VARIOUS TYPES OF "PAJANG"

by
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ARSTRACT

The longline and trawl fisheries of Indoesia are still in the investigational/experimental stage. The training of crews in the use of modern longline and trawl gear as distinct from the indigenous "rawai" and "dogol" gear has only been undertaken by the Government (Sea Fisheries Service and the Institute of Sea Fisheries) during the past few years.

It is as yet too early to draw exact comparison of the relative efficiencies of the introduced and the indigenous fishing methods and equipment.

Preliminary results suggest that the "rawai" unit, operated by two men produce about 2.500 kg. per annum, giving a gross income of Rp. 12,500 and expenses approximate Rp. 820.

The much more elaborate longline unit, involving a large powered vessel, 40 baskets of gear and a crew of 17 has a calculated gross income of Rp. 360,000 with annual expenses of approximately Rp. 215,000.

The indigenous "dogol" unit is estimated to return a gross income of Rp. 7,800 p.a. (3,120 kg. fish), at general annual expenses of approximately Rp. 900. The crew consists of a captain and two fishermen.

Experimental trawl fishing during 1955, by the 24-metre trawler *Andjuna* crewed by a captain and twelve men, yielded 147,977 kg. valued at Rp. 378,342. Nett profit from the year's operations was Rp. 50,278.89.

Data relating to four types of "pajang" seine-nets from different areas is presented. These nets produce from 15,000-30,000 kg. p.a. and are operated by crews of 9-16 men.

INDIGENOUS TYPES OF FISHING CRAFT IN INDONESIA

by
Salam
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ABSTRACT

There are hundreds of types of fishing vessels in Indonesia.

Almost every fishing area has its own type of fishing vessels, consisting of lar size, medium size as well as small size vessels, which are quite different from the typ in other areas.

These differences are due to the fact that the construction of these vessels is n based on a fixed design, but they are constructed according to methods and dimensio inherited from ancestors.

Of the many types of fishing vessels used in Indonesia, only the following a described:

I. **Vessels from Kendal (Central Java)**
1. "Perahu Kondeng" — ca. 12 m. length, Cost Rp. 10,0
2. "Perahu Kementing" — ca. 9 m. „ , „ 4,5
3. "Perahu Tjompreng" — ca. 7.5 m. „ , „ 3,6

II. **Vessels from Panarukan (East Java)**
1. "Perahu Pajang Besar" — ca. 11.5 m. length, Cost Rp. 8,0
2. "Perahu Koang" — ca. 8.5 m. „ , „ 3,7
3. "Perahu Pantjingan" — ca. 6 m. „ , „ 3,6

III. **Vessels from South Sumatra**

A. Lampong Area

Vessels are mainly of the Java types and most fishermen are Javanese.

B. Bengkulu Area
1. "Perahu Pantjing" — ca. 5.5 m. length, Cost Rp. 2,0
2. "Perahu Pukat Tepi" — ca. 8 m. „ , „ 2,5

C. Palembang Area
1. "Sampan Bagan" — ca. 7 m. „ , „ 3,3

IV. **Vessels from Central Sumatra**
1. "Perahu (Biduk) Pantjing" — ca. 12.5 m. length, Cost Rp. 1,6

V. **Vessels from North Sumatra**
1. "Perahu Sampan" (Tandjungpura) — ca. 14.5 m. length, Cost Rp. 18,0
2. "Perahu Sampan" (Tandjungbalai) — ca. 12 m. „ , „ 13,5

MECHANIZATION OF FISHING CRAFT AND THE USE OF IMPROVED FISHING GEAR IN CEYLON

by

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ABSTRACT

Since about the year 1925, attention has periodically been focussed on the stagnation ...e local fishing industry, and the need to introduce modern fishing craft capable of working ...e fishing gear has consistently been advocated by those who studied the subject. This ...rt shows the stages through which the evolution of more effective fishing operation has ...ressed, both in the gradually increasing use of mechanical propulsion for boats and in the ...tion of more modern gear and techniques by local fishermen. No reference is made in ... report to the operation of deep-sea trawlers, which is a phase of development which has ...erto not influenced the local fishing industry to any appreciable extent. A report on the ... vl Fishery has appeared as Bulletin No. 6 of the Fisheries Research Station.

...RELIMINARY ACCOUNT OF THE RECENT EXPERIMENTS IN MECHANIZED FISHING IN BOMBAY WATERS USING SMALL VESSELS

by

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ABSTRACT

An account of the mechanized fishing in the waters near Bombay during the fishing ...on of 1955-56 using five small vessels is presented. The data are based on the results of ...ration of five small vessels with different gear—the reekie boats, *M.F.V. Bumili* and *M.F.V. ...mpa* (seine nets and bottom gill nets); *M.F.V. Bungada* (midget otter trawl); *M.L. Meena* ...lon gill nets) and *M.L. Durga* (shrimp trawl)—of the Government of India, Deep Sea ...ing Station, Bombay. A total of 196,757 lb. (approximately 89 metric tons) of fish was ...led by all the boats from the Bombay fishing grounds for the season. The data have been ...mined with reference to the fishing efforts of these boats and quantity as well as quality of ... fish caught. A comparison of the relative efficiencies of these operations has been ...mpted based on catch per haul per unit of gear for each of these boats.

PROCESSING AND STORAGE OF SALTED HERRING
(*SARDINELLA PERFORATA* CANTOR)

by

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ABSTRACT

Fresh herring (lapad), *Sardinella perforata* Cantor, were salted in concentrated brine tions prapared from refined and common solar salt each containing one tenth of 1 per cent um benzoate or potassium nitrate.

The fish were immersed in the brine for 30, 60, 90, and 120 minutes and sun-dried rwards for two days. One-half of the dried salted fish was packed in moisture-proof con- ers (sealed cellophane) and the other half exposed at room temperature.

Those immersed for 30 and 60 minutes contained the correct amounts of salt ranging n 11.30 to 17.11 per cent dry basis. Preservation with sodium benzoate or potassium ate and packaging in moisture-proof containers enhanced the keeping quality of the salted luct.

Two species of molds were isolated from the dried salted herring.

INTRODUCTION

Handling and processing of fish and its ducts in the Philippines are much handi- on account of the tropical climate and umidity that hasten fish spoilage (Lafont, . Because of its highly perishable nature, usually preserved by freezing or icing, , smoking and canning.

Refrigerated or iced first class fish demands price in the open market while the lower of fish are either salted, dried or smoked. st instances, in the Philippines, drying r without salt is the common practice for ving fish, as lessening the moisture content fish renders it unfavourable to the growth oilage micro-organisms. Avery (1950) d that dried fish with 20 per cent moisture last longer than those with higher mois- ontent. Dry salting is another million- nterprise next to the bagoong and patis ries with the production centres in Cebu, te, Samar, Occidental Negros, Bicol re- Zamboanga and Sulu Archipelago. Being source of cheap protein food, the manu- e of salted fishery product is, indeed, a hing enterprise in many fishing regions country.

The quality of salted fishery products is affected primarily by the method of processing, temperature and purity of salt. The use of solar salt containing a high percentage of impurities results in the production of inferior quality products that spoil easily on storage, as the accumulated moisture thereof serves as a good medium for the spoilage organisms. Hamm (1950) reported the following chemical analysis of typical solar salt available to fish salters in Manila:

	Per cent
Sodium chloride	92.00
Calcium sulphate	1.30
Magnesium sulphate	3.90
Magnesium chloride	2.70
Other impurities	0.10
Total	100.00

Because of the poor quality of solar salt used by fish salters the resulting products are usually inferior in quality. In the majority of cases the products are too salty as there is no standard method of salting them. The utilization of poor grade salt in the absence of a standard method of processing, results in the production of non-standard products.

. *Indo—Pacific Fish. Coun.*, **7** (II—III): 87—92, 1957.

The use of refined salt in the processing of salted herring will, in one way or another, lead to the improvement of this important fishery commodity. At the same time, storing the salted fish in moisture-proof containers will not only produce sanitary but more presentable products.

The purpose, therefore, of this study is to determine the advantage of using refined salt over the common solar salt in the salting and storing of herring. At present, there is no definite standard method available for the processing and storing of salted herring in the Philippines. It aims also to use one tenth of 1 per cent sodium benzoate or potassium nitrate and pack the finished product in hermetically-sealed containers to prolong its storage.

EXPERIMENTAL METHOD

In order to differentiate the quality of salted herring according to the nature or kind of salt used, brine was prepared from refined and common solar salt, with or without the addition of known quantities of chemical preservatives.

Preparation of brine. — In this study both refined and common impure solar salts were used. To determine the efficacy of some food preservatives, one tenth of 1 per cent of sodium benzoate or potassium nitrate was used (Gilbert, 1953). The brine portion without the chemical preservatives served as control.

Brine salting. — In the three kinds of saturated brine fresh herrings were allowed to remain for 30, 60, 90 and 120 minutes, then dried in the sun until the moisture content was less than 40 per cent (Lafont, 1952 b). In another study of fish salting, an artificial drier is intended to be used instead of the sun.

As soon as dried, one half portion of each sample of the salted fish was packed in a moisture-proof container (sealed cellophane) and the other half exposed at room temperature and set aside for observation.

Chemical and microbiological determination. — The sodium chloride contents of salted fish before and after drying were determined (Table II).

The microbiological examinations of the product while in storage were also undertaken.

RESULTS AND DISCUSSION

A rough estimate of moisture is figured out in the following manner: ximately one-fifth of a fresh fish is t moisture-free solid and by subtracti weight (one fifth of the weight of fre from the weight of dried fish the am water left in the fish is ascertained. T a longer time of storage the moisture co dried fish should be not more than 40 p (Lafont, 1952 b). Using the aforementione computation for determining moisture the salted herrings were found to cont than 40 per cent moisture in two days good sunshine. At this point, the dr were set aside for observation.

Organoleptic test. — The dried were subjected to organoleptic tests, the of which are enumerated in Table I. immersed in saturated brine for 30 or 60 had an ideal taste, not salty at all and the characteristic biting taste, whil allowed to stay in brine for 90 minut slightly salty with an ideal taste and Those brine-salted for 120 minutes wer salty although not as salty as the com products that are allowed to stay i overnight.

Appearance. — Generally, the drie herring were yellowish in colour bu salted with refined salt solution were co to slightly yellow. The portions that wer hermetically were excellent in appearan

Dryer (1949) and Luypen *et al* claimed that the yellowing of salted products is not due to bacterial contam but due to traces of iron. Normal sal contains 1 to 2 p.p.m. iron but the conta ones usually contain more than 30 p.p.m

Hygroscopy. — As shown in Table quite apparent that the product, irrespe the quality of salt used, had the tend absorb moisture from the air, the am moisture absorbed increasing in the containing more salt of impure quality (T while those packed in hermetically seal tainers were perfectly dry and gave no loose water on the surface.

Chemical preservatives. — Two k chemical preservatives were used to inh

of mold on the fish while in storage. ith of 1 per cent sodium benzoate or the mount of potassium nitrate were added ely in the saturated brine.

The salted herring without preservative al) started to get moldy in a period of one while those that were hermetically sealed ot attacked by mold. Within two months r, all were heavily moldy.

Those that were preserved with sodium te and packed in hermetically sealed con- were not moldy even after several months age and retained the original appearance product.

A German patent describing the curing ing revealed that salted fish containing an 10—17 per cent salt have a pleasant nd odour. In this connection, herring for 30 or 60 minutes in concentrated brine ne ideal salt content.

Sodium chloride content. — Analysis of the mediately after salting revealed that those l with refined salt contain higher per- e of salt than those treated with crude alt, given the same length of soaking in ne. Also, the moisture content is lower se treated with pure salt, because in the s of osmosis a greater amount of water in h was replaced by the salt. From 30 to inutes of fish salting the percentage of salt ed ranged from 4.05 per cent to 7.61 per when pure salt is used, while with crude e amount of salt absorbed is 4.07 per cent per cent. It is quite evident that the ities present in the crude solar salt retard sorption in the fish muscle.

Immediately after drying, as is shown in III, the sodium chloride content of dried herring is higher in those treated with alt than those with crude solar salt. It is apparent, therefore, that in salting fish the of soaking in brine is shortened when pure salt; the taste, of course, is also much ved. Using the concentrated brine made pure salt the ideal length of soaking time –60 minutes. With crude salt, soaking s 60—90 minutes and soaking the fish for inutes is definitely too long, producing salty products. Thus, the common ce in the Philippines of salting herring ight involves waste of salt and produces, as well, a highly salted product that has practically lost its food value.

Microbiology of salted herring. — The two species of molds were isolated from the dried fish, inoculated in Sabourands' Glucose Agar and incubated at room temperature. After four days there was a rapid growth of colonies, at first white, then attaining the characteristic colour of greenish yellow.

Using the lacto-phenol cotton blue mounting medium, mounts were made on slides. Microscopically, the greenish-yellow molds with enlarged tips forming a vesicle from which the flask-shaped sterigmata were produced, covered the swollen surface. Conidea were cut off from the tips of sterigmata, forming unbranched chains, giving appearance to the apically swollen conidiaphore. This kind of mold is known as *Aspergillus glaucus* (Zinsser *et al*, 1979), which is a common and troublesome contaminant in foods. They appear on culture media as a felt-work often thickly-dotted with black which upon standing turns greenish-yellow.

The other colonies grew very rapidly and filled the petri dish in a few days with dense cottony aerial mycelia, which were white at first, and turned grey afterwards. Under the microscope the stolons (runners) were clearly visible, connecting groups of unbranched sporangiophores, arising at the point of contact of the stolons.

The swollen tip of the sporangiophore, the columella, extended into the sporangium and was clearly visible when the sporangial wall ruptured, liberating the spores. This mold was a typical *Rhizopus* sp.

SUMMARY OF RESULTS AND CONCLUSION

Herring (lapad), *Sardinella perforata* (Cantor) were salted in concentrated brine made from refined and crude solar salt at different intervals of 70, 60, 90 and 120 minutes. To the brine was added one tenth of 1 per cent of sodium benzoate or potassium nitrate. Immediately after drying, samples of the salted herring were packed in moisture-proof containers (cellophane) and another portion exposed at room temperature.

Those that were packed in hermetically sealed containers remained excellent in appea-

rance and no deposit of salt was visible to the naked eye, although the color turned slightly yellow. The taste of the product brined for 30 or 60 minutes were not salty while those brined for 90 and 120 minutes were too salty. It is evident, therefore, that herring should be brine-salted for 30 to 60 minutes to obtain an improved product. At the same time, the taste of those salted with refined salt is much better than those salted with the crude solar salt. The absorption of salt in the fish as shown in Tables II, III and IV is definitely much faster when refined salt is used.

The controls and those exposed at room temperature were moldy in one month and within two months those preserved with sodium benzoate or potassium nitrate were moldy, while those that were sealed in cellophane were not attacked by molds.

It is evident, therefore, that herring should be brine-salted for 70 or 60 minutes to obtain an improved product. It is also evident that herring should be salted in brine solution made of refined salt, preserved with one tenth of 1 per cent of either sodium benzoate or potassium nitrate and packed in hermetically-sealed containers.

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Observation	Immersed in solar salt solution for						Immersed in refined salt for					
	30–60 minutes		90 minutes		120 minutes		60 minutes		90 minutes		120 minutes	
	Exposed	Sealed	Exposed	Sealed	Exposed	Sealed	Exposed	Sealed	Exposed	Sealed	Exposed	Sealed
Yellow Colour	+	–	+ +	+	+ + +	+ +	–	–	+	–	+ +	+
Moist	+ +	–	+ +	–	+ +	–	+	–	+ +	–	+ +	–
Salt	+ +	+ +	+	+	+ +	+ +	+ +	+ +	+	+	+ +	+ +
General Quality	Ideal	Ideal					Ideal	Ideal				

–: Absent; + : mild; + + moderate, + + + : pronounced.

Table II. Moisture and Sodium chloride contents of salted herring, *Sardinella perforata* (Cantor) immediately after brining.

Length of soaking in saturated brine (Minutes)	Moisture content after brining		Sodium chloride content after brining(%)			
	Refined salt	Impure solar salt	Refined Salt		Impure solar salt	
			Fresh basis	Dry basis	Fresh basis	Dry basis
30	72.69	72.82	4.05	14.83	3.07	11.30
60	69.38	70.98	5.24	17.11	1.21	11.61
90	68.53	71.53	6.02	19.13	4.76	16.72
120	65.91	68.14	7.61	22.32	4.99	16.05

Table III. Moisture and Sodium chloride contents of herring immediately after soaking in saturated brine.

Length of soaking in saturated brine (Minutes)	Moisture content after drying (%)		Sodium chloride content after drying (%)			
			Refined Salt		Impure solar salt	
	Refined salt	Impure solar salt	Fresh basis	Dry basis	Fresh basis	Dry basis
30	34.12	33.01	10.48	15.01	8.86	13.23
60	34.53	33.35	13.57	20.73	10.67	16.01
90	37.06	33.68	14.27	22.67	10.70	16.13
120	36.36	34.82	15.57	24.47	13.60	20.57

Table IV. Showing the sodium chloride content of herring immediately after soaking in saturated brine.

Length of soaking in saturated brine (Hours)	Sodium chloride content of salted herring (%)	
	Refined salt	Impure solar salt
$\frac{1}{2}$	4.05	3.07
1	5.24	4.24
$1\frac{1}{2}$	6.02	4.76
$2\frac{1}{2}$	6.13	4.66
$4\frac{1}{2}$	7.64	5.59
$6\frac{1}{2}$	11.33	9.97

STUDIES ON THE PRESERVATION OF MARINE PRODUCTS BY COMBINED USE OF SALT AND PRESERVATIVES

by

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ABSTRACT

Experiments with Z. F., Sorbic Acid, Boric Acid, Aureomycin and Sodium Nitrate d to solution of Common Salt demonstrate that their preservatives improve the keeping ties of dried salted fish.

INTRODUCTION

he use of abundant salt alone to pre- h in the tropical zone or in the summer f the temperate zone is inadequate for servation of fish for long periods, and rable damage to the product occurs from osition, in unsuitable inconvenient localities or at places without cold storage facilities. To avoid such damage the author has undertaken this study.

MATERIALS AND METHODS

Preservatives used for the purpose are as follows:

Table I. Preservatives and their Concentration.

Preservatives	Concentration as % of Preservatives in 15% NaCl Solution
-NO_2-2-furfuryl acryl amide)	0.002
orbic Acid)	0.050
ureomycin)	0.001
	0.100
ic acid)	0.500
	0.002
	0.050
	0.002
	0.001
	0.002
	0.100
	0.002
	0.500
	0.050
	0.100
Con. 1 (Control)	15.000
Con. 2 (Control)	20.000

Preserving Method

Cod meat and round raw Jack mackerels were washed, and the author immersed 7 kg. of each in 10 litres of each preservative solution (Table I), weighed with 3 kg. of stones. The preserving solutions were stirred frequently. The contents of the vessels were turned over several times. After 50 hours the fish were taken up from the vessels and dried for 89 hours in air. To each sample was added 10% by weight of salt containing the preservatives, and each sample was again pressed. After 2-3 days, the samples were dried in air and st 16°—24° in June and at 23°—32° in August.

RESULTS

The preserving effect of the co use of preservatives and salt was determ organoleptic tests and by the quantitativ sis of basic volatile N for cod meat. R the organoleptic tests of the preserved shown in Table 2, whose figures indi days during which the preserved fi considered eatable.

Table II. Effects of preservatives on the keeping quality of salted dried fish.

Preservatives	Material	Cod meat		Jack mackerels		Cod meat		Jack ma
	Temp.	23° — 32°C				16° — 24°C		
	Moisture	50—46	42—38	48—25	40—36	50—46	42—38	48—45
	Concentration	Days during which the preserved product remained ed						
Z.F.	0.002	45—60	90—100	40—50	50—60	60—80	90—110	50—60
Sorb.	0.020	30—35	50—60	25—30	45—50	50—60	80—90	35—45
Aur	0.001	45—60	90—100	45—50	50—60	60—80	90—110	50—60
$NaNO_2$	0.050	30—52	40—50	18—25	20—25	45—50	60—70	40—50
B.	0.500	10—14	35—45	8—10	12—14	20—25	40—45	12—15
Z.F.	0.002							
+		60—80	100—120	50—60	80—90	90—110	120—140	70—90
Sorb	0.002							
Z.F.	0.002							
+		60—80	110—120	50—50	90—100	90—120	130—150	80—100
Aur.	0.001							
Z.F.	0.002							
+		50—60	100—110	70—80	80—90	60—90	110—120	60—70
$NaNO_2$	0.050							
Z.F.	0.002							
+		45—60	90—100	50—65	60—70	60—80	90—100	50—60
B.	0.500							
Sorb.	0.020							
+		65—75	100—110	60—60	60—75	80—90	110—120	70—80
Aur.	0.001							
Sorb.	0.020							
+		50—55	100—110	50—60	40—50	70—80	90—100	55—60
$NaNO_2$	0.050							
Aur.	0.001							
+		55—65	100—110	50—60	60—70	80—90	110—120	60—65
$NaNO_2$	0.050							
NaCl	15.000	10—10	36—40	8—10	12—15	20—24	40—45	12—14
NaCl	23.000	20—30	50—60	14—20	18—24	30—40	60—70	20—30

ıe author observed the quantitative analy-
a of basic volatile N of preserved cod
preservatives and salt. As a result of
eriment, the author found nearly the
ts as organoleptic observation on Jack
ls preserved by combined use of preser-
and salt. So the table concerning the
tive analytical data of basic volatile N of
t preserved by preservatives and salt is

CONCLUSION

1. About 5% of salt may be saved by a combined use of salt and food preservative in dried fish manufacture. The use of preservative results in a much longer keeping period than that obtained by use of salt only.

2. Among food preservatives, Z.F. and aureomycin have the strongest preservative power, and sorbic acid comes next.

FISH FLOUR

by
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ABSTRACT

Preliminary investigation of "fish flour" as a source of high quality protein and of :rals for human consumption, has been undertaken at the Lambaga Makanan Rakjat. A enient method of preparation is described.

The biological value of the protein of the product is high, comparable to milk protein. keeping quality, as determined by physical, chemical, and biological methods was found e good. Samples 8 months to more than 2 years old, proved to be still of good quality.

INTRODUCTION

ish protein has a high biological value, able to that of milk protein. Although the possibility of increasing the catch fish, in Indonesia, there still exists the y of preservation and distribution to the areas. The ordinary methods of preser- such as canning and cold storage are ly not practical for this country. Even ventional salting-drying proves to be atively expensive.

The manufacture of fish flour on the other may help provide the fish protein and ls in an inexpensive form that keeps well g periods of time. The fish flour industry ady more or less established in Chili; v factories are already manufacturing fish other areas of the world such as Thailand, lippines and South Africa. The product sold comparatively cheaply and within ch of the poor people. It is a concentrate quality protein and of essential minerals, easily packaged and transported form. ver, it is already cooked and may be y used as food.

MATERIALS AND METHODS

The fish flour that was used in this gation was manufactured at the Industrial ch Institute (Balai Penjelidikan Industri) karta. The method used was as follows:

The fish was cleaned and eviscerated, lt was added and cooked under pressure ounds for 15 minutes. The bones became a result of pressure cooking. The pro- as pressed in a hydraulic press to remove as much as possible of the oil and water. Fifteen parts of powdered salt per 100 parts of original nett weight was added and well mixed. The product was dried in a current of hot air to less than 5% moisture, and powdered. The fish used was "Selar" (a carangid).

Freshly prepared samples were chemically analysed for protein, fat, ash and chloride. A sample, a year old, was microbiologically analysed for seven essential amino acids.

Animal feeding experiments were carried out on products after storage for different periods in cork-stoppered jars in order to determine the biological value of its protein. Young white rats were fed diets mixed with fish flour samples and the growth and food consumption were measured. The fat in the fish flour was first extracted with ether in a soxhlet extractor. The protein content of the defatted flour was determined, and diets were made to contain 10% protein, all derived from fish flour. The diets contained, besides the fish flour, starch, sugar, peanut oil, and sufficient minerals and vitamins.

A group of animals was placed on each of the diets. There was one group on a diet mixed with 3 months old fish flour, another on a diet with a 6-month old sample, a third on an 8-month old sample, and a fourth on a diet mixed with skim milk powder. The amount of the food consumed was measured daily and the gain in weight was recorded once a week. The feeding was continued for a period of 5 weeks, at the end of which the total food consumption and weight gained for every rat measured, and the gain per gram of protein nitrogen consumed was calculated.

Observations were also made at different periods of storage on flavour and colour.

To prevent rancidity of the oil in the flour during storage, antioxidants were separately added to the product, as the products of rancidity e.g. aldehydes, ketones and their polymers, might not be nutritionally desirable.

The concentration of antioxidant used was 100 g. per kg. fish flour. It was dissolved in a little ether and sprayed on the ground fish after pressing and just before drying. The finished fish flour samples were kept in closed glass jars for a period of 3 months. They were then examined for colour of the flour and the extracted oil.

The antioxidants tried were:

1. Tenox B.H.A. (butylated hydroxyamisole).
2. Tenox B.H.T. (butylated hydroxytoluene).
3. Tenox P.G. (propyl galate).
4. D.P.P.D. (diphenyl phenylenediamine).

RESULTS AND DISCUSSION

The freshly prepared samples had the following composition:

Protein	75.0 %
Fat	3.0 %
Ash (total)	17.0 %
Chloride (as NaCl)	7.5 %

The microbiological analysis for 7 essential amino acids gave the following results:

Lysine	10.3 %
Methionine	3.3 %
Threoeine	5.5 %
Tryptophane	1.3 %
Isoleucine	4.8 %
Valine	5.6 %

The values compare very favourably with those reported in the literature for fresh fish muscle protein. They show that the concentration of none of these essential amino acids is low as compared with high quality animal protein.

The biological value of the protei fish flour samples are recorded below:

Diet mixed with	Gain per g nitrogen cons
3-month old sample	3.16 g.
6 „ „ „	3.16 „
8 „ „ „	3.19 „
skim milk	3.28 „

These results indicate that the pr the fish flour is of high biological value, as high as that of milk protein.

They also show that storage for 8 does not decrease the biological value.

The fish flour has fresh fish During storage in closed vessels it g develops a somewhat objectionable smell is later on replaced by an acceptable fla dried fish. This process of aging tak months under ordinary storage conditions oxidation of the fat is evidently respons these changes. The colour of freshly p product is grey, which gradually turns lowish then brownish on storage. The fa fresh product is yellow in colour but product is dark brown. If kept in clos tainers the product keeps well for a p more than one year. The flavour of a y sample is still acceptable to the Ind people.

Tenox BHA, Tenox BHT and DPP prevent the oxidation of the residual fish at the same time they prevent the aging fish. The development of the dried fish was delayed, which is probably an und action. Tenox PG showed no action.

It was felt that the use of antioxi not desirable in fish flour for use in Ind Besides the aged fish flour, it is probabl rable to manufacture a fish flour that fresh. To do so, further investigation is sary.

If the temperature of the hot air u drying the product is high enough and t is stirred constantly (as in large scale m ture), the fish flour will be dry in a few m Then it can be packed in cans, under a n or carbon dioxide atmosphere and sealed.

Fish flour, thus prepared will p keep its fresh flavour for long perio further investigations are required.

FUTURE USE OF FISH FLOUR

rupuk made at the Institute, which d 10% aged fish flour, had an acceptable nd taste, which shows that the product l use in the krupuk industry. The price ap krupuk is very high due to the cost shrimp, whilst the product made with r will certainly be much cheaper.

In Thailand the product is now being used in a school children feeding programme. It is incorporated in stews and soups or sprinkled on rice. It might be possible to make the same use of fish flour here for school children, hospitals or institutions.

Another possibility is the incorporation of the flour with glutinous rice in making "lemper" or similar products with casava flour such as "otak-otak".

AN EXPERIMENTAL INVESTIGATION OF DRY FISH MANUFACTURE

by

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ABSTRACT

The importance of the dried fish industry in Ceylon and the disadvantages in the methods of fish curing are discussed. Results of some chemical and bacteriological es into the preservation of fish by salt are described.

After investigating several methods of curing, the most satisfactory results were ned by a process involving the removal of guts and gills and the extraction of surface by a dip in 10% brine prior to salting in brine maintained at saturation. But salt was found to be insufficient to prevent bacterial decomposition especially due to is of red halophiles, to which however a 0.5% aqueous solution of citric acid proved itory and a 2% solution bactericidal. The viability of common food poisoning pathogens urated salt was also decreased and the growth of fungi prevented by this concentration ric acid. Citric acid besides its bacteridical and fungistatic properties, increased the l rate of salt penetration, thus shortening the period of time during which the fish ost liable to decompose.

The salt-citric acid protection permits slow air drying without deterioration; apart its superiority to direct sun-drying, the process is thus made independent of adverse her conditions.

INTRODUCTION

he manufacture of dried fish in Ceylon ne time one of the major industries of id. Deraniyagala (1953) has traced the uses that led to its decline, which were osition of taxes on the product as well as ve levies on the salt upon which the mainly depended.

urthermore, the increase in facilities for age, transport and distribution of fish l the use in its fresh form of a greater on of the raw material formerly available ing. Various attempts to revive the such as the abolition of the fish tax, an duty on dried fish and a scheme for ed salt production had limited success.

Nevertheless, even today the dried fish is of considerable local importance. esh or cured, is a rich source of protein of which has been reported as one of the nutritional deficiencies in the local diet, lly among the poorer classes (Nicholls Silva, 1954). Fresh fish requires special s, such as refrigeration, for its transport rage, which limit its distribution making the cured product the only form of fish available in many areas. Curing fish is also a useful cottage industry as it often supplements the meagre income of fishermen enabling them to make the best use of occasional surpluses and of less popular varieties. Further, several fishing areas such as the islands off the northern coast are out of contact with the fresh fish markets and curing is the only way of utilizing the catch.

In recent years the quantitative increase in the catch of rough (unpopular) fish in the trawler landings (Sivalingam, 1954) also makes the economic utilization of these varieties one of the important problems of local commercial trawling. Curing will partly solve this problem by the conversion of this unmarketable fish into marketable cured fish.

In Ceylon, fish are cured commercially by three main methods. On the hot sands on the beaches of the dry zone, small species are dried whole without any treatment or addition of salt. By its nature this method has a very limited application. The second method uses salt only in a dry cure but relies on a hot sun for drying

ndo—*Pacific Fish. Coun.*, 7 (II—III): 101—106, 1957.

and is thus altogether dependent on the weather. The third method uses "Coraka" (the dried carpels of the fruit of *Garcinia cambogia*, whose active preserving agent seems to be an acid), in a wet cure which gives a type of pickled fish. Methods of preparation and variations in flavour from district to district suggest that this last method is a complicated cure involving fermentation. Other types of cure, such as smoking are done on so small a scale that their output is negligible.

All these methods have remained antiquated and unhygienic, and they result in a product of poor quality, the exposure for sale of which has often acted to the detriment of the entire cured fish industry. Rehabilitation of the industry therefore necessitates not only an improvement in methods of manufacture but also the education of the producer to the recognition of the need for sanitary curing yards, clean utensils and the use of clean salt and undecomposed raw material. The present work was directed towards the solution of one aspect of this problem to the development of a satisfactory commercial curing process for dry-salted fish.

METHODS AND RESULTS

The preparation of dry fish may be divided into three stages: preliminary treatment of raw material, salting and drying:

Preliminary treatment of raw material: Fish are not bled at sea and it seems impractical to do so on board local craft. Large size fish are gutted on board trawlers but even this practice is unfamiliar to most of our fishermen. After the catch is landed, the first operation found necessary is the removal of gut and gills as retention of these organs soon leads to serious decomposition. The head and backbone sections tend to discolour due to exudation of oil which is also liable to turn rancid. It is therefore suggested for good quality fillets that these bony portions be processed separately from the flesh. Our experiments have shown that the presence of scales does not interfere with curing if the fish are filleted nor are incisions necessary for a successful cure. As the flesh was not bled, surface and diffused blood was effectively removed as suggested by Jarvis (1950) by brining for about half an hour in approximately 10% solution of salt.

Salting: In order to simplify the investigation of the salting process, preliminary work was done on cleaned cubes of flesh of catfish *surus (Netuma) thalassinus* (Ruppell) one varieties commonly chosen for curing.

Rubbing dry salt into incised flesh f by sun-drying proved unsatisfactory salting appeared uneven and the expos attracted flies during the early stages of t Rubbing with dry salt allowing a brine with the addition of saturated salt solu cover the flesh, proved more satisfactory brine protected the flesh and ensure contact with the salt. Peterson and We (1951) reported similar observations. Th strength of the salt solution requir investigated by the immersion of pieces in brines of varying salinity. The stable s was found to be a saturated solution co solid salt. Flesh in 10% and 15% brine posed in two days, in 70% brine in 13 d 100% brine in 20 days while flesh in sa brine with solid salt remained stable for o months. In all solutions fat separated ou on the surface and after a few days supp fungal growth which was skimmed of entire solution was changed occasionall the fungus could not be removed co from solution.

When flesh is immersed in bri moisture in the flesh diffuses into the br salt from the brine penetrates into the fle follow this process, analyses of moistu salt were done on flesh immersed in sa brine containing solid salt. Before imm moisture was 77% and salt negligible. A days the moisture content fell to 55% a increased to 21%. After a week the m was still 55% and salt 21%. This ratio re a 27% w/w salt solution in the flesh, a s which is saturated. In other experime salt content rose above 27% probably du absorption effects of the material. Hence two days salt penetration is complete a salt is in equilibrium as a saturated solu the flesh and in the outside liquor. A sa solution in the flesh is possible only with containing solid salt.

The oil content of the flesh sh decrease during processing. Raw flesh co 22% oil calculated on dry weight, which de to 11% after salt saturation and to 4% af longed air drying.

Drying : Several workers have urged the n of air-drying in preference to sun- in the manufacture of dried fish. Jarvis d points out that oxidation, rusting and rn set in warm climates if sun-drying tised. Linton and Wood (1951) have that under conditions of rapid drying an ous salt-protein crust is formed which further drying. This crust is more likely under local conditions of sun-drying. A disadvantage of sun-drying is its depen- on the weather.

The rate of air-drying is controlled by a of factors, chiefly humidity, air velocity mperature. Air-drying under cover is than sun-drying and consequently tends an encrustation of salt crystals which erably detracts from the the appearance of al product. Similar surface deposits have bserved by Cooper and Wood (quoted by and Wood, 1945) during slow air-drying. rmation of these deposits was reduced by ease in air velocity. The wind velocities main curing stations are well within the m range recommended by the Torry ch Station (Katugampola, 1950 unpublis- But the figures for humidity (Observatory l Reports) are outside the range of 40-50 ted as optimum by Linton and Wood). Fortunately, the high air velocities and emperatures at our curing stations com- e for the high local humidity.

Drying on the beaches in covered sheds permit free circulation of air thus provides ently favourable conditions for a satisfac- ure if the tendency of the flesh to pose can be controlled during this compa- ly slow process.

Control of Bacterial Decomposition: Prese- n is basically an interruption of the natural es which occur in dead tissue. These es are oxidative, autolytic and bacterial in . The preservative action of salt is chiefly o the withdrawal of moisture from the s thus inhibiting the growth and activity oilage bacteria. Among other factors ed are the direct action of the salt itself e tissues, the enzymes and the bacteria an, 1949; Tressler and Lemon, 1951).

The general bacterial flora of fresh fish caught in our waters include *Micrococcus*, *Achromobacter*, *Flavobacterium*, *Pseudomonas* and various bacillary forms. Most of these are proteolytic and able to cause rapid spoilage changes in the fish muscle, but are generally inhibited by a concentration of approximately 15% salt. However, certain strains of marine bacteria are able to tolerate high concentrations of salt while a few find salt essential for their growth. These latter are called 'Halophiles' and certain pigment producing groups, the 'Red Halophiles', together with certain fungal molds, are the chief agents responsible for deterioration in salted fish.

The control of bacterial reddening and fungal molds has been recognised as one of the major problems of the salt fish industry. (Lobell and Puncochar, 1947). Improvements in processing methods, use of pure sterilised salt and chemical additives to the final product have been suggested as a means of control in this connection. Sterile methods of operation are impractical under local conditions of manufacture and even if it were possible to obtain a sterile final product, exposure during storage and transport will make it liable to subsequent contamination leading to spoilage. Chemical methods of control therefore seem to us the only alternative.

Various chemical additives are in commercial use in different countries. These include boric acid, benzoic acid, sodium or magnesium benzoate and sodium propionate. Their use in the industry is restricted either by their cost or the terms of Food & Drugs Acts. Recently, the use of sorbic acid has been recommended for dry salted fish but it has proved ineffective against red halophiles. (Boyd and Tarr, 1955). In local commercial practice lime juice (citric acid) vinegar (acetic acid) and 'Goraka' (tartaric acid) are used as preservatives. Goraka and vinegar are used to obtain a distinctly flavoured specialty product while citric acid is used mainly for its preservative action. Therefore the use of citric acid as a chemical preservative for dry fish was investigated.

Mixed strains of red halophiles were isolated from salt fish and cultured using the improved Lockhead's Medium (Dussault and La Chanee, 1952). A concentration of 0.5% citric acid incorporated into the medium was sufficient to inhibit the growth of these bacteria.

Concentrations beyond 2% killed them and inhibited almost all types of contaminating fungi.

Survival of bacteria of epidemiological importance was also studied from inoculations made into sterile juice from fish muscle, equal volumes of sterile juice and saturated salt, and similar juice and saturated salt to which had been added 2% citric acid. Within the first two hours all the bacteria were killed by a saturated salt solution containing 2% citric acid, while *B. coli*, *Staph. aureus*, *Strep. faecalis*, *Shigella* and *Salmonella* survived this period of time in fish juice with or without an equal volume of saturated salt. Experiments on the survival of these organisms in salted fish cured in brine containing 2% citric acid gave closely similar results.

Besides its bactericidal and fungistatic properties, citric acid increased the initial rate of salt penetration thus shortening the period of time during which fish is most liable to decompose. In experiments using 5-gram samples, a time lag of 10 minutes was observed between the time taken for the salt concentration to reach the same value (in the 5-15 range) in two pieces of flesh, one in salt and the other in salt-citric acid. This time lag increased to one hour when samples weighing 50 g. were used. Such an increase becomes significant under conditions conducive to rapid spoilage such as the high temperature prevailing in the tropics. The application of these results in a commercial process was achieved by using as brining solution, a 2% citric acid to which excess salt was added. Although the water from the flesh diffusing into the solution diluted it (by about 50%). sufficient citric acid penetrated into the flesh to attain the inhibitive range of over 2% in the final product. When maximum protection was required, a 2% solution was made available from the start of the cure by adding citric acid equal to 2% of the total water (free and in fish) present in the curing vat. For salting 100 lb. of catfish fillets (obtained from 200 lb. of gutted raw material) it was found necessary to use 4 gallons of water to which were added 35 lb. of salt and 2 lb. (2% of total water) of citric acid. After three days brining (to ensure complete salting) the loss in weight of the fillets was10 lb. After complete air drying the fillets weighed 55 lb. (35% moisture). Heads and bones (approx. 50% of raw material) processed separately yielded 45 lb. of cured product. In com practice it should prove possible to re- salt-citric acid solution thus making the more economical. The quantities of s citric acid can be reduced if the product r no protection during the curing process, happen under conditions giving a rapid h cure. The minimum amounts would sufficient to saturate and citric acid eq to 2% of the final moisture content in th fish.

A rough marketing test on this in a polythene wrap showed that it a more to the educated group (clerks etc.) the working class group. The appeal la arily in the hygienic appearance of the while the complaint against it was that i the flavour of dried fish sold in the mark flavour of market dried fish is largely decomposition during curing. As far local consumer was concerned, our dried different from the market varieties wit he is familiar and therefore had to be a on its own merit as a new product.

DISCUSSION

Based on the experiments descri improved method for the manufacture o fish may be suggested. This method i brining, air-drying and the use of citric a preservative. The main advantage process is the stability of the product manufacture and storage. Further, a earlier noted, slow air-drying can be p only if the product can be protecte spoilage during this period. The in tion of citric acid provides a process w independent of weather conditions. T bility and protection are achieved increased rate of salt penetration, the bac action of the citric acid in the presence and the preservative action of the salt it

The entry of the salt into the essentially osmotic in nature. Whe penetrates, it causes the precipitation proteins and the saturation of the residu in the cell. Penetration of the salt cease a saturation value of 27% w/w is reache the cell. Values observed above this rati experiments suggest that salt is also a by various cell constituents, probably the reticulum. Citric acid in common wit

acids influences the entry of salts by
ng the permeability of the cell membrane.
e taken for the salt inside the cell to
sufficient concentration is thus lessened.

he antibacterial effect of the salt-citric
nought to be due to the enhanced activity
alt in the presence of acids. It has been
y Nunheimer and Fabian (1940) that in
e of food poisoning *Staphylocci*, the
of acid reduces by 50% the amount of
chloride necessary for germicidal action.
lso been reported that certain groups of
a including aerobic and anaerobic
earers are inhibited by concentrations
that permit the growth of lactic acid
which produce sufficient lactic acid to
ent the inhibitory action of salt (Jacobs,
The susceptibility to salt in acid is even
in the case of proteolytic and peptolytic
(Ericson and Fabian, 1942).

n addition to the effect of the hydrogen
nheimer and Fabian (1940) have reported
germicidal and antiseptic properties of
re also due to the un-ionised molecule
r the anion or both. Hess and Gibbons
in similar observations have noted that
cid and lactic acid were more effective
etic acid, although this is a stronger acid.
periments also suggest that while acids
he activity of salt as a preservative, the
radicle is also of significance in this
tion.

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RECENT WORK ON FISHERIES FOOD TECHNOLOGY IN THAILAND

by

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ABSTRACT

The Technology Section of Thai Department of Fisheries is in its preliminary es of development with restricted personnel, equipment and funds. The Section's vities in the past year have strictly been of a preliminary nature.

A survey of the salt fish industry has supplied information on common production tices and on the quality of salted dried 'pla thu' *(Rastrelliger* spp.*)* at present marketed. the basis of experiments the authors give information on yields, salt penetration and ydration when dried in the sun and in a mechanical dryer. The results of some age tests indicating the relationship between moisture content and keeping quality are presented.

A quick method for moisture determination in salted fish, that may prove useful he industry, is described.

Experiments in the canning of ark shells ('hoi kraeng', *Arca* sp.) tunny-fish, ito, and pla thu are described. The rather small tunny-fish caught in the Gulf of iland yields a product comparable to that commonly known in the world market, le the bonito required special seasoning.

Information is given on a method developed for the preservation of fish intended meal production, using immersion of the fish in a weak solution of sodium nitrite. s pointed out that nitrite should only be used by factories with competent technical sonnel, and that ordinary brine (salt) offers a safer solution for general use.

A co-operative programme aimed at the introduction of fish flour for human con- ption is reported and some problems of the development of the micro-biological flora ing storage of the fish flour are indicated.

IMPROVEMENT OF KEEPING QUALITY OF PINDANG

by

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ABSTRACT

According to old preservation methods "Pindang" (preserved fish in earthen pots) eps only for several days. Due to this and because of lack of transportation, distribu- n to far away places has become a real problem. To bridge the distance from the ast to the mountain regions, efforts have been made to improve the keeping quality of product by using better pots. The porous clay pots traditionally used were first rilized by soaking for 2 days in a 1% chlorine solution. The rubber sealing rings were ated with 2% potassium meta-bisulfite solution.

After filling and processing, the sealed pots were treated externally with two ats of a 4:1 paraffin-resin mixture at 70° C to seal the pores.

With improved processing methods, the "pindang" maintains its quality for 9 months.

ECONOMIC ASPECTS OF FISH PROCESSING

by
Eddiwan
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ABSTRACT

This article gives a brief description of the present situation of fish distribution in nesia, the necessity and the methods of fish preserving, and also a consideration of possibilities of expanding the processing of fish and its effect on the economic and o-economic situation of the Indonesian people.

INTRODUCTION

ish processing, in Indonesia with its ve island areas, forms the most important rom the view point of fish production, the en's income and the distribution of fish from the sea and inland fisheries. A rable part of the fish catch cannot be sh, but reaches the consumer in several ed forms. It is estimated that 70% of fish and 40% of the freshwater fish of Indonesia are preserved.

Of Indonesia's theoretical need of appro- y 1,600,000 tons of consumption fish y, only 250,000 tons are consumed fresh.

NEED FOR PRESERVATION

The most important factors necessitating servation of the main part of the fish are:

Production Centres: The fish producing n Indonesia are not equally distributed. espect to the sea fisheries, the highest ducing areas are:

i. The area along the North Coast of Java, with the "mayang fisheries".

i. The North East Coast of Sumatra, especially at the Bagan Siapi-api Area surrounding the mouth of the Rokan River, with the "djermal fisheries".

i. The Northern part of Celebes, Minahasa and the group of islands of the Moluccas along the southern edge of the Pacific Ocean, well known as the "tuna area".

iv. The West and South Coast of Borneo, known as the areas of the "sero", the bamboo stake trap, with which the "kembung" *(Rastrelliger kanagurta)* is mainly caught.

v. The Macassar-Strait, where the "torani-fisheries" (flying fish) are operated with floating bamboo traps.

vi. The area of Bali Strait and South of Bali.

vii. The Thousand Islands in the Bay of Djakarta and the waters in the surroundings of Bangka and Billiton.

The most productive areas of the inland fisheries are:

i. The river and swamp area in South and East Kalimantan (Borneo).

ii. The Tempe Lake (South Sulawesi), Celebes.

iii. The *Chanos* ponds in the Residency of Surabaya.

iv. The fish culture area of West Java.

The fish yields in these high producing areas cannot be absorbed locally and must therefore be exported into territories where fish is needed. However, facilities for the adequate transportation of fresh fish and also cold storage in the territories concerned do not exist.

Concentrated Consuming Centres: The fish consuming areas are, on the contrary, concentrated, mainly in the Island of Java.

The theoretical minimum need for fish consumption for Java is about 1,200,000 tons, that is to say 200% of the Indonesian fish production in 1955. Of this quantity, only 12% is supplied by the yield of the seawaters surrounding the Island of Java.

Other fish producing areas find a good market in Java, and large quantities of fish are transported to this Island.

Transportation and Handling Facilities: Communications between the producing and consuming areas are inadequate.

Bad communications also occur between the landing and consuming centres in one region. Due to this, the fishermen are forced to preserve the fish catch, or to suffer a loss. Besides, there is no proper transportation available, by land or sea. Transportation of fresh fish exceeding 12 hours spent in hot air and shipped with equipment available in Indonesia will be ruinous for the fish. Transportation by land is carried out by trucks, packed in baskets with ice but is very expensive and is not profitable over long distances. The Railway Department does not reserve freight cars with refrigeration equipment specially for fish transport, so that fish must be shipped, packed in baskets with ice, by ordinary freight vans and the lack of refrigerated vans makes such shipments very risky. Transport by sea is very poorly developed in Indonesia. The few carrier boats are primarily used in waters of the Bay of Djakarta carrying the catch from the 'muro-ami' fisheries.

Other fishing vessels are suitable for catching purposes only, due to their small tonnage; and trading vessels also lack refrigeration facilities for fish transportation.

Well equipped cold storage plants are also not yet established in Indonesia, so that fish cannot be kept for a long period and must be sold or preserved immediately.

Unstable Price: From the above, it is evident that fish landings which are far above the demand of the local consumers must be preserved, and it frequently happens that 90% of the catch has to be preserved. This is not very profitable for the fishermen, since prices in the producing areas are very low, compared with prices in the consuming territories. Sometimes the difference between prices goes up to 500% and sometimes prices for preserved fish of species in one region are lower than t fresh fish.

The high prices of fish in the con territories are due to:

1. The high transportation charg
2. The many intermediaries b producer and consumer.
3. Shortage of fish production.

Unfortunately, the low prices producing areas are depressing for the fis since such prices do not adequately the pains-taking labour at sea. If the trolling factors can be minimized or re the fishermen can obtain better prices consumer can purchase the fish at low Low fish prices not only hurt the fis from the material point of view, but son also have a bad psychological effect. It fre happens that in certain areas fisherm unwilling to catch more fish than neces order to maintain reasonable prices, a they are in fact able to increase their catc in some cases an "extra production" fisherman does not mean an "extra incon on the contrary denotes a "lower incom therefore the fishermen have always to ta account their catch in proportion to the and purchasing power of the local fish For intensifying fish production, this wo be very beneficial, especially for Indone according to the fishermen's point o however, it is just plain logic.

IMPORTANCE OF PRESERVATIO

Fish processing therefore takes portant place in the industry because:

1. The fishermen are able to pro their activities, the fish is not
2. The production of preserved be used to minimize the defic in the nutrition of the people.
3. Distribution of fish to other con territories is possible, in a as processing renders the fi perishable.

From the industrial point of vie processing forms a source of income, owner of the industry and his labour

he fishermen's families, for whom fish ng forms an auxiliary income. Further- sh processing industries also provide for that group of people who supply h needed processing materials.

he salt fish industry in Indonesia not less than 100,000 tons of salt , valued at 30 millions rupiahs. Other es for packing materials, such as rattan boo baskets, clay pots, share in the ment of the processing industries too. g that 400,000 tons of the total fish are preserved, yielding 200,000 tons d fish, the trade in fish processing should value of about Rp. 2,000 millions . It is clear that fish processing forms contribution to the economic activities ndonesian community, especially for the of the processing industry and for the connected with it.

PRESERVATION PRACTICES

he methods for fish processing in Indo- e still simple, but nevertheless provide ct with a tenability of 2 or 3 months.

. Usually fish are salted and dried. ish are put round into wooden boxes lt added, and the somewhat bigger ones en. The ratio of fish to salt needed for ation is: 1 kg. salt to 2—10 kg. fresh fish. ntity of salt depends on the size of the e preserved and on the consumer's taste. eing placed in brine for about 12 to 20 the fish are then sun-dried. If there is heat, the drying takes one day only. ethod of drying is common and cheap erefore applied in all regions. Since ia is situated in the Tropics, this drying re is practiced throughout the year, in the rainy season.

. A part of the surplus fish catch is d for the so-called "pindang". The bigger species of 15 cm. or more are in clay pots with salt added. The fish sold together with the pot. This method essing occurs frequently in East Java, Java and on the Bawean Islands.

3. In North Celebes and the Moluccas ation is affected mainly by smoking, lly for tuna species.

4. Canning, especially for fish has not been firmly established yet in Indonesia. There are food canning factories in Bali, Sumbawa and Djakarta, which have canned fish in small quantities, and the Government is setting up canning factories at Kota Baru (S.E. Borneo) and at Ambon. The canning factory at Kota Baru will produce canned mackerel *(Rastrelliger)*, whereas the one in Ambon cans tuna (Skipjack tuna etc.).

CONCLUSION AND RECOMMENDATIONS

With respect to the fish production potential of the Indonesian seawaters and the waters of the big islands and its relationship to the shortage of animal protein (the total shortage is about 1 million tons annually), fish processing presents many opportunities for development.

A greater production implies directly an increase in the processed products, for areas outside Java, a higher fish production does not mean a greater fresh fish consumption locally, but increased quantities available for processing.

In addition, attention should be given to the following factors in order to develop the processing industry, so that the processed products can be sold at the lowest rate to the community.

1. Communication, especially transport by sea must be improved. At least fish must be able to be transported from the producing centres to places with good commercial relations and within easy reach of the Island of Java as the most important consuming area.

2. Techniques of fish processing must be improved, in order to produce better quality preserved fish which keep longer. Better keeping qualities make possible an extensive distribution of the preserved fish as a commercial article. Better quality of the preserved fish obviously fetches higher prices. These two factors would ensure higher prices for fish landed in the producing areas.

3. Fish canning must be executed in an inexpensive way. A high production cost tends to depress fish prices in the producing areas, and the prices for canned fish still remain high. At present, canned fish is expensive and, therefore, only within the reach of the more wealthy members of the community. If the prices for

canned fish can be reduced, the market will be then enlarged and its canning production intensified.

It is also suggested that a closer cooperation between the I.P.F.C. countries, especially by the exchange of information concern production of the most commonly used processed fish, i.e. dry or wet salted fish be of value to all concerned.

ROLE OF PISCICULTURE IN RURAL ECONOMY IN ORISSA

by
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ABSTRACT

During the last few years through the efforts of the State Department of Fisheries in lishing Fish Seed Centres for major carp fry, good quality fish fry have been sold at ded rates to pisciculturists in the villages. The fry consists of quick growing carps like *catla*, *Labeo rohita*, *Cirrhina mrigala* etc. The economy of the piscicultural industry in ion to the income of the fish farmer has been studied in selected cases both with reference y and fish and it was generally established that the total income of a village could be antially augmented by pisciculture. On the results of this study, Government Fisheries been handed over to Gram Panchayats (village organisations consisting of all the bers of the village, the executive body being a board of elected directors). The Panchayats oans from the Government to reclaim tanks and they purchase the fry from the Fisheries rtment and take up pisciculture as an industry. The results of operations in a few cases been analysed and are found very encouraging.

INTRODUCTION

In the State of Orissa (area 60,136 sq. opulation 15 million) most of the houses d huts. In the deltaic area, the s raised and the house is built with mud d by digging a pond as a result of which every house has a pond in the back yard. gh drinking water is mostly obtained ells, the pond is used for bathing, wash- tensils and also irrigation of the kitchen . Fingerlings of carps are usually ob- by capturing them in paddy fields or from weirs and stocked in the pond and form the only source of household fish supply, chasing power of the average villager mitting the consumption of fish bought e market. The number of such tanks is ingly large and a sample survey has as many as fifty to one hundred tanks in area from 0.2 to 1 acre in a village population of 1,200.

Productivity in new tanks is reported to l but the majority of the tanks are found a neglected condition. They are deeply and full of weeds. Even though the is aware of the value of the silt, lack tal does not enable him to renovate the The steep nature of the embankment itated by the limited space, is undoubtedly sible in creating a quick deposit of silt but this cannot be avoided in many cases. Accurate data on the productivity of the ponds is not available as the villager consumes the fish (catching by small cast or drag nets) and once the tank becomes unproductive it is left to itself. A number of such neglected tanks in a village affects the sanitation to a great extent.

MATERIAL AND METHODS

Village tanks are both annual and perennial. In the absence of knowledge about scientific manuring and the selection of fish seed the productivity does not seem to leave a margin of profit to provide for periodical draining and/or other renovation. One of the problems has been to improve fish cultural practices and educate the tank owners. To this end various experiments have been conducted:

(i) to introduce an organisation by forming tank owner's co-operatives,
(ii) to make more capital available to owners,
(iii) to provide technical knowledge, and
(iv) to supply good quality seed etc.

RESULTS

The following data give some indication of the productivity of small tanks in the Orissa State, both annual and perennial, utilised for fry and fish culture.

Indo—Pacific Fish. Coun., 7 (II—III): 113—115, 1957.

Table I. Production from pisciculture in an annual tank at Cuttack.

Area—0.75 acre

	Manure		No. stocked	Period of rearing in days	Yield in lb.	Gross Income in Rs.	Nett in
	Variety	Quantitiy					
1949	Nil	Nil	4,000	162	169	155- 0-6	1
1950	Compost	4,120 lb.	4,000	210	560	383- 6-0	3
1951	Nil	Nil	6,000	166	313	225- 3-3	1
1952	Compost	8,240 lb.	1,000	180	285.5	158- 5-6	1
1953	Nil	Nil	2,000	196	284	190-10-0	1
1954	Nil	Nil	2,000	194	123.6	85-14-0	
1955	Cow dung	8,240 lb.	2,000	210	595	349-11-0	2

Average gross income per year per acre.....Rs. 276.; Average nett income per year per acre.....Rs. 201.

Table II. Production from a perennial private tank in Balasore.

(Area—0.92 acres; Year 1954-55.)

Manure—Kitchen refuse, compost, with urine of cow etc.
Stocking—Fingerlings of carps @ 18,000 per acre.
Yield—2,158 lb.
Nett Income—Rs. 1,570-12-0.

Table III. Production from a perennial tank run by the Chikalkhandi Grampanchayat

(Village Executive Committee).

(Area of tank—4 acres)

Year	No. of fingerlings stocked	Yield per acre	Gross Income
1950	10,000	Nil	—
1951	10,000	1,035 lb.	Rs. 2,759-0-0
1953	3,600	960 lb.	Rs. 2,555-8-0
1955	4,600	450 lb.	Rs. 1,260-4-0

Table IV. Production from a perennial nursery farm at Choudwar.*

Year 1951.

anks in farm	Total area	Yield in fingerlings per acre	Value	Size of fingerlings
7	2.85 acres	300,000	Rs. 1,500	13-50 mm.

anure used—Lime, bonemeal, compost, cow dung.

The gross yield from paddy in Orissa is mately Rs. 180 per acre, from jute Rs. Rs. 400, from sugar cane Rs. 350 to Rs. The results given in the tables show that of fish can be compared with any cash nd whatever area is available for fish in a village in the form of pits, retting ponds and swamps can contribute to the nic uplift of the village with suitable outlay and organised fish culture. The t effects of the silt which is removed ne tanks would be to add fertility to the nd the reclaimed tanks would be free nosquito larvae. Besides, development in ence of fish culture is progressing rapidly periments are being conducted to increase elds from all types of tanks, specially to double crops of fish from nurseries and d paddy from paddy fields.

The Department of Fisheries, Orissa, has ted to utilise all types of water areas in s and sixty extension centres have been p. Experiments have been made in ting road side depressions, pits left after making, natural depressions, jute retting tc., into nurseries. These are manured and stocked with spawn and the average yield although low (30,000 fingerlings or Rs. 300 gross per acre) gives some production and the pits are free from mosquito larvae. Even small pits 20' square have been used for fry culture.

The utilisation of village tanks and pits to yield an income not less than paddy, as would be clear from the above facts, would add to the income, indirectly reduce incidence of disease and make protein food available in the village. In order to achieve this end, the necessity of introducing organised fry and fish culture, availability of capital and the provision of technical knowledge on a scale greater than hitherto, seems clearly indicated.

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AN EXPERIMENT IN THE ORGANIZATION OF MARKETING CO-OPERATIVES IN THE CHILKA LAKE

by

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ABSTRACT

Chilka Lake with an area of 400 square miles has an average output of 5 million of fish a year, but trade was in the hands of middlemen merchants who purchased catches at a low rate and had the benefit of the consumers' market in Calcutta. There only one co-operative in a moribund condition functioning from 1929. The society was the nature of a multipurpose store and the fishermen took little part in the managem All persuasion from this Department to the fishermen to have joint marketing directly Calcutta failed as they had little faith in the Department. In 1942 the Lake was ravag by a very bad cyclone and the Department conducted relief operations, which created g will, and one society was organized at Gajapatinagar. As was expected, direct dealing in market earned a handsome profit for the fishermen and thereafter the progress of co-operat development was very rapid around the Lake. It was, however, necessary to keep c Departmental supervision on the day-to-day business and periodically a society was allow to run itself. In many cases due to factions or misappropriations the societies bec moribund and had to be revived. Certain controls were established to protect the socie in an equitable manner from unfair competition on the part of the middlemen mercha and this helped the progress of the societies.

An analysis has been made regarding the capacity of the fishermen to run their c business, the benefits that accrued from the marketing effort and the difficulties experien in making quick progress. It was found that the fishermen were not sufficiently educa to be left on their own for the time being, but at the same time they could gradually given greater responsibilities.

It is significant that this organization did not receive any loan from Governmen Bank and although there were party factions, societies could be reorganized. Accumulat of money in the hands of certain societies, run by fishermen by caste but actually middlem led to litigation and considerable loss. The controls have now been removed and progress of the organization is under observation. An experiment was made to organize individual societies into a Federation but it was found that without constant guidance constituents showed little interest in it. An analysis was made of the causes and it found that the office bearers of individual societies preferred their own marketing arran ments, mostly on account of personal gains offered by the marketers in Calcutta.

EPORT OF THE FISHERIES DEPARTMENT'S ECONOMIC SURVEY OF THE PURSE SEINE INDUSTRY OF KUALA KEDAH

by

Fisheries Department, Federation of Malay and Singapore.

ABSTRACT

The purse seine fishery of Kuala Kedah is one of the largest and most advanced ries in Malaya with an obvious potential for development along modern lines. A survey undertook extensive field work during October-December 1951, following a thorough tative initial study and the data collected have been checked and amplified by frequent visits. A detailed account of the equipment, organization of the fishery and marketing m are given together with analyses of over-all production and production in relation fort, supported by extracts from the daily diaries of 21 purse seine units during the d October-December 1951.

Data on the operational and maintenance costs of the units, estimates of capital stment and assessments of income levels, with a description of the systems of payment peratives are given.

The survey revealed the intimate connection between capital finance and marketing the need for most careful basic surveys before plans for innovations in marketing methods e introduction of technical developments are implemented.

PAPERS MENTIONED BY TITLE ONLY

The following Technical Papers were received and the Council directed that the titles be recorded in these Proceedings.

57 / TECH

Observations on the artificial feeding of bangos' fry, *Chanos chanos* (Forskal), by A. Ronquillo and E. Villameter.

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24. On the young of the Black marlin *Eumakaira nigra* Nakamura, by Shoji Ueyanagi.

25. Length frequencies of Big-eye tuna caught from the Indo-Australian Archipelago area, Koya Mimura.

26. The concentrated spawning areas of the Big-eye tuna in the Western Pacific, by Shoji Kikawa.

27. Studies on variability of hooked-rates of Yellowfin tuna by longline fishing—1. A trial to estimate confidence limits of mean hooked-rates using data of the catches of commercial vessels, by Tadao Kamimura.

35. Necessity of fishery products processing and its effect, by Yoji Asada.

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59. Growth characteristics of four sp pond fish in Hong Kong, by T. C

62. Marine fish marketing in rural —A successful experiment in Ho by I. Peterson.

FISH CULTURE ON PADDY FIELDS IN INDONESIA

by

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INTRODUCTION

Evidence derived from libraries, official reports and oral information received from y farmers points to the fact that fish culture in rice fields started in the middle of the century. So to date we look back about a hundred years. Moreover, it can be stated his technique began in West Java *(Preanger Regencies)* on rice fields situated in the bourhood of centres of pond culture mainly found in the vicinity of well known ous schools such as the ones near Tjiandjur and Singaparna. After finishing their e many students brought this practice to their places of origin and thus many religious en became pioneers of fish culture in paddy fields. Other circumstances of importance e spreading were:

1. the establishment by Government of the rights of the people on their lands and products which caused new paddy fields to be created.
2. the spreading of information, propaganda, guidance and technical advice by Government Agencies, initially the Civil Administration, later on the Agricultural Extension Service and finally the Inland Fisheries Extension Service, and
3. the good prospects in various regions.

In Central Java this form of fish culture was established by the proper authorities rds the end of the 19th century *(Purwokerto and Muntilan)* and in East Java in the 1924.

Conditions outside Java are as follows:

: Around Bukittinggi this culture rted in 1894. The people of Padangsid- puan began to be interested in 1930, as esult of propaganda by the Agricultural tension Service.

Lebong and Muaraman the Sundanese m West Java, formerly working the gold nes near Redjang, started fish culture in ddy fields.

: A start was made in North Celebes wards the beginning of the 20th century, a result of propaganda by the Civil dministration of Tomohon.

enado-area began in 1897 and Southern elebes in 1936 as a result of the work of e Inland Fisheries Department.

d Lombok : Propaganda by the Inland sheries Department began about 1953.

Subsequent spreading is shown in the following table (data for the whole of Indonesia, acreage in ha, yield in tons of consumption fish).

Year	Acreage	Yield
1951	24,000	2,444
1952	24,146	2,967
1953	48,748	5,259
1954	65,167	9,088
1955	90,492	9,160

It might be mentioned here that the increase in yield in 1955 is not in accordance with the increase in acreage as a result of untoward climatic conditions.

Next to the yield of culture operations in paddy fields the yield of capture operations on about 4 million ha. paddy fields may be estimated at about 6,000 tons of fish annually.

ndo—*Pacific Fish. Coun.*, **7** (II—III): 119—154, 1957.

METHODS OF FISH CULTURE ON PADDY FIELDS

Formerly, fish used to be grown in paddy fields in West Java after the harvest of the rice. One or two months after the single crop of rice grown during the wet season, had been harvested the fields were prepared and stocked with fingerlings measuring 5—8 cm. in length and cultivated for 3 months. So the original method was to grow fish once in a season. In Bukittinggi this method is followed till the present time. The consumption fish cropped was used by the farmer himself. However the increased circulation of money in the villages made fish an object of trade.

Later on, two periods of 2 months each were used on well irrigated and easily surveyed paddy fields. Not later than one month after the paddy was harvested, the fields were prepared.

When fish was grown only once a year in fields where rice was grown once a year too, the practice became known as "palawidja", the same as the present "second crop" method, whether this period was the dry season or the wet season. In Tjurup and Kepajang this period coincided with the wet season.

As a result of the extension of fish culture in paddy fields as second crop and the increased demand for fry, centres were established where fry about 15 days old were nursed until 5—8 or 8—11 cm. long.

After World War I the farmers were induced for various reasons to plant rice more than once a year in regions where the water supply was adequate. However, as fish was cultured in these fields as second crop the time available for such culture became short. The more rice was grown, the more fish culture was hampered. The period of 6 months was decreased in this way to 1—3 months and became more and more a mere "interval" between 2 crops of rice.

Accordingly, this method became known as the "interval method". Originally the aim was consumption fish as was the case in the previous method, but a gradual shift towards the production of fry became apparent. In this period the urge to grow fish become stron so was the demand for fry. Therefo possibility of raising fry to larger si considered. Afterwards fish were grown paddy fields along with rice until t weeding, in fields not far removed from of fish culture and villages.

The above picture is mainly true Java. A different development took p other regions on Java and elsewhere, in tion with the irrigation and the way of of the rice, for example in East Java.

In Bali and Lombok, the Inland F Department fostered the growing of cons fish along with rice as the first stage.

Although West Java can be consid be the cradle for fish culture, the cultiv consumption fish along with rice started in East Java. Data on production c income, collected in 1950 are given Appendices.

Second Crop Method

Usually an entire region grows this method at the same time, and t demand for fry rises as does the price. reason the farmer will try to obtain suffici slightly before his rice is harvested, by c some from a trader or fry grower. Som he buys the fry himself in small numb time and stores it in a small pond on his co or in specially prepared paddy fields wh rice was harvested beforehand. Such fi often planted with a special variety of must be within easy reach for supervisio

One or two weeks after the rice h harvested the field is prepared for fish In the first place the irrigation can cleaned and overhauled, sometimes by co labour. Afterwards the dykes are repai

In the plains, at places far from the a couple of fields are often combined a dykes constructed. Sometimes new dy made on the inner side of the old one when the danger of holes dug by *Monopte* is *Paratelphusa* apparent. This practise observed in high plains, as in Bandung. fields in the plains situated near vill irrigation canals are usually prepared dually. Fields on sloping areas are prep

way. No new dykes are constructed

he acreage of a combined field depends istance from the main irrigation canal. ther removed, the larger the field and er the dykes, with the result that the ill be deeper. Thus three groups of an be distinguished in a large complex nutual source of water.

) ponds consisting of a single paddy fields.

) ponds consisting of a 2 or 3 paddy fields.

) ponds consisting of more than 3 paddy fields.

xploitation of each group differs from r.

n group a) the dykes measure 50 cm. in rom the moat to the top. The dykes are om earth piled up during the digging of t. Recently constructed dykes will lose in height as a result of sinking of the t the base the dykes are at least 50 cm.

The dykes of groups b) and c) measure) cm. in height and the base is 80—100 cm. epending on the size of the pond.

A piece of bamboo put through the dykes inlet and outlet. The height of the depends on the desired height of the n the field, 20 cm. above the base of the type a), 50 cm. in type b) and 80 cm. in

The outlet slants slightly towards the ; the inlet towards the inside. Its mouth cm. under the surface. The inlet is ed with bamboo strips, in order to bar red fish and rubbish.

The paddy straw is sometimes left on the nd only cut under the surface when the ung paddy is fairly high, or the straw is ed down with a piece of bamboo. Some- the dry straw is cut at the base and piled heaps. The space between two heaps res 5 cm.

The circular moat created when the dyke ngthened is overhauled in the next stage ts width is enlarged to 50—150 cm. depending on the size of the field. The depth is 20—30 cm. in the centre. In large fields, where the straw has been piled up cross moats are constructed as well.

When all preparations are finished, the fields are filled in 2 or 3 days with water to a maximum capacity in order to test the strength of the dykes. Before the field is stocked the water polluted by the straw is replaced by clear water.

Management of the fields involves inspection of dykes, the inlet and outlet twice a day. During heavy rains the inlet is closed. About 2 weeks after stocking of fry, the paddy shoots and other aquatic vegetation are cut under the surface or pulled out, which operation is repeated a few days before the fish is cropped, in order to facilitate cropping.

In the case of second crop cultivation, divided into 3 periods, cleaning takes place every month. During the day time birds are scared away, notably towards the end of May, which is the end of the dry period, by men sitting in small bamboo huts on long stilts. In order to capture *Monopterus* small dykes are placed on the heaps of paddy straw, baited with snails. Cropping takes place in the morning or the evening. During cropping noxious fishes and other pests are removed. Edible aquatic animals are captured by the labourers during cropping and kept as part of their pay.

After cropping the heaps of decomposing straw are worked under dykes, and moats overhauled and weeds pulled out. When the paddy straw is not cut but knocked down at the beginning of the period, it will be cut after the harvest and laid out in long rows, one or two days before the second stocking.

Common carp is the main fish grown, other species of fish are of minor importance. The aim of this form of culture is two fold:

a) to raise fry 3—5 or 5—8 cm. long,

b) to grow consumption fish.

In order to obtain fry 3—5 cm. in length, the field is stocked with fry 1 cm. long, 15 days old, at a rate of 60,000—100,000 fry (6—18 bowls). The growing period lasts 3 weeks, and the loss amounts to 50—60%. The crop is counted by bowls of 500 fry each.

To raise fry, 5—8 cm. long, the field is stocked with fry, 2—3 cm. long, at a rate of 2 bowls of 700 fry each, grown for 3—4 weeks; the yield is 800 fry. Loss: 40%.

Fry 8—11 cm. long is grown from fry 5—8 cm. long, stocked at a rate of 2,000—3,000 for 20 days. Loss: 45%.

With the main stock an additional stock of bigger fish is used. To fry 15 days old are added about 500 fry (5—8 cm. long)/ha. A stock of fry 5—8 cm. long is supplemented with not more than 10% fish measuring 8—12 cm., while a stock of fish 8—11 cm. in length is supplemented with not more than 10% fish weighing 100 gram each.

A summary of the number of growing periods and ways of exploitation in various regions is given below.

1) Tjiandjur Area

During half of the year 5 periods of 3 weeks each.

a) First stock: Fry 15 days old. Result: Fry 3—5 cm. long. Rate: see above.

b) Second stock: Same as first, or Fry 3—5 cm. long. Rate: see above.

c) Third stock: Fry 3—8 cm. long. Rate: see above.

d) Fourth stock (after the fields have been tilled, ploughed and harrowed): Fry 15 days old. Rate: 15% higher than first time.

e) Fifth stock: Fry 3—5 cm. long. Rate: 20 bowls of 500 fry each.

2) South of Bandung

a) Three times stocking with fry 15 days old, then once more in order to obtain consumption fish. Stocking rate: first and second time-40,000-60,000/ha. Result: Fry 5—8 cm. long; third period 20,000 fry (2—3 cm. long)/ha. Fourth period stocked with the bigger fish from the previous periods, in order to obtain consumption fish. Rate: 6,000/ha. Loss: 50% first and second time, 30—40% third time and 20—30% fourth time. From first to fourth period: 40 days.

b) Three periods of 40 days period: Stocking material: F cm. long. Rate: 6,000—8000/h 20—30%. Second period: R percentage of loss similar Third period: Rate=2,000 fish cm. long) per hectare, quick of previous periods. Loss: 1 On fields downstream in the of city: Length of period 4 In areas further removed: 2 only, 50 days each. Stockin 3,000—4,000/ha. In some still further from the city, on only is practised. Rate: 2,0 8—11 cm. long or 3,000 fry 5 long per hectare. Length of 3 months.

3) East of Bandung (Rantjaekek, T Madjalaja, Sumedang)

Usually 2 periods of 50 days. king rate, depending on fertility fields. 1,000—2,000 fry 5—8 cm. l hectare. Loss: 20—30%.

4) Other regions in West Java

In other regions, such as S. W. Banten etc., fry stocking rates f between 1,000 and 2,000 fry 5—8 cm. 2,000—4,000 fry 3—5 cm. long. per Loss: 20—30% and 30—40% respectiv

Duration of period about 3 m single crop each season. Rate dep fertility, estimated according to the rice in quintals.

i. 40 qu./ha. dry—Needed 60 11 cm. lon fry 5—8 c per qu.

ii. 30 qu./ha. dry—Needed 50 11 cm. lon fry 5—8 c per qu.

iii. 30 qu./ha. dry—Needed 40 11 cm. lon fry 5—8 c per qu.

ittinggi

A single period per season of 4—6 ths. Stocking takes place after the l has been ploughed and sometimes owed. Rate: 20,000—50,000/ha., fry 5 cm. long or 60,000—100,000/ha., fry 2 cm. long. Cropping takes place gradu-. The bigger fish (50 g.) are captured t and sold as consumption fish. Loss: 0-60%.

araaman and Lebong (Bengkabulu)

Fish grown as second crop from tember-February. Some fields are com-ed and made into a pond, with 50 cm. of ter. One period per season. Well-to-do ners crop once only, others twice. The face of the water is cleaned in excep-nal cases only. 6—8 thousand carp fry asuring 5—8 cm. or 10,000 fry measuring 5 cm. are stocked. Loss: 70%. The aim consumption fish weighing 0.75 kg. each.

nahasa

Fish is grown as second crop for 6 months. Rate 1,000/ha. of 8—11 cm. single period of growth. Aim: consump-n fish of 250 gram. Loss 10%. Other way: 00/ha. of 5—8 cm. in 2 periods. Aim: nsumption fish of 100 gram. Loss 20% per riod.

Recently the second way is the more quent one. In places where fish is grown 2 periods the yields differ greatly, hough all circumstances are equal. If e straw decomposing under water is of quickly mineralising variety the higher eld is obtained in the first period, if the aw decomposes slowly the higher yields e the ones of the second period. The ird period always yields less than the evious ones.

The number of additionally stocked h usually amounts to 10% of the primary ock.

An experiment carried out at Buah-tu (South Bandung) in 1936 the fields ere stocked at a rate of 3,000/ha. with rp fry weighing 5 gram. Carp fry eighing 50 gram were added in various mbers. The period of growth was 50 days. he soil was Bandung clay. Results are ven in Table I.

Table I. Effect of mixed stocking of small and large carp fry on the yield.

Percentage big carp	Total yield (Kg.)	Increase in grams per fish	
		Fry	Big carp
5	96.90	79.9	231.8
10	97.94	78.7	236.7
15	105.0	65.6	201.6
20	107.8	77.6	183.5

According to the individual increase in weight of the big carp, their stocking at 10% gives the best results. Calculation of the rentability also gives similar results. The experience of the farmers is in accordance with this finding as they mainly use an additional stocking of 5—10%.

Another experiment at Buahbatu compared green with red coloured fry. According to the farmers the loss of red carp is higher in clear water than that of green carp. Length of period: 50 days. Rate: 3,000/ha. of fry weighing 5 gram, and 10% of fry weighing 100 g.

Table II. Mortality of green and red carp fry during culture.

Fry	Percentage of loss	
	Green	Red
Small	23	45
Big	3	12

Another experiment investigated the result of a mixed stocking of carp with *Trichogaster pectoralis* (Regan).

Stocking rate of carp: 3,000/ha. of measuring 6—10 cm. plus 10% of fry measuring 12—15 cm.

Stocking rate of *Trichogaster:* 300/ha. of fry measuring 10—12 cm.

The result was disappointing. After 50 days the *Trichogaster* showed only 2% of the increase of the common carp. Individual increase of *Trichogaster* amounted to 15 gram, that of the carp to 50 gram.

Cultivation of Fish in between Two Rice Crops

Preparation operations consists of overhauling of dykes, ploughing and harrowing. In case the fields will not be used for the cultivation of consumption fish, the dykes are constructed in accordance with the needs of the cultivation of the paddy. Moats dug in order to facilitate cropping are constructed at the time of cropping. For the cultivation of consumption fish, hoe-ing and ploughing are considered necessary but harrowing is not. The bamboo inlet and outlet pipes are fitted in such a way that the depth of the water is 10 cm. for fry and 20 cm. for consumption fish. The duration of this method is from 1 to 3 months, depending on the frequency of the rice culture, each period lasting one month.

Originally the aim of this method was the procurement of consumption fish for the labourers on the fields. But as the area used for fish culture increased, the fields were more and more used to produce fry.

Stocking rates and sizes of the fry do not differ much from that used in the "second crop", in similar soil and of same duration. They are slightly different in East Garut (Wanarakja). Here fry 15 days old, are stocked at a rate of 20—30 thousand /ha., in order to raise 10,000 fry measuring 3—5 cm. Part of this crop is not sold but restocked at a rate of 4—5 thousand/ha. and grown up to a size of 8—12 cm. (2—3 thousand fish/ha.) in 1 month. This product is usually stocked in fields with growing paddy.

When the total duration of the growing period is 3 months, fry are either produced twice, or fry are grown for 1 month and consumption fish, for 2 months. The size of the fry to be grown to consumption size depends on the distance of the field from the house of the operator. When short distances are involved, fry, 5[illegible] long, are used, otherwise fry 8—[illegible] long at rates of 2,000/ha. in the fi[illegible] 1,000—1,500/ha. in the second case 30% and 20% respectively.

Formerly, fish measuring 10— and weighing 20 gm. were considere consumption fish in Sukabumi and Tj and sold at a high price. Compare the period before the Japanese occ this means a distinct shift, as duri period fish weighing 30 gm. was co as consumption fish.

From a biological point of v latter process must be the more ec one as less maintenance food for the involved. But this is not proporti the volume and weight of the fish.

A slightly different form method is found in East of Tjiandju fish are grown after the harvest of so (*Glycine soja* L.) grown as dry secon The fish are stocked after the ploughed and all remaining vegeta worked under. Culture fish me 8—12 cm. are stocked at a rate of 1 The period is 1 month and the per of loss 10—20%. Cropping: see seco method. The product is exceptionall

Fish Culture along with Rice

Preparation consists of raisi dykes, because higher ones must structed for the fish than those nee paddy only. Inlet and outlet pi fitted as in the case of the secon method.

If the dykes of fields us cultivation of consumption fish are finished when the soil is tilled, t finished gradually during the fi second weeding.

At the first weeding the rice plant to the dykes are pulled out and replanted centre. In the open area along the dy circular moat is dug, and the earth is enlarge and/or to raise the dyke. This continued during the second weedin sloping grounds, only the dykes weake the construction of the moats are streng Cross-moats are constructed during the

soil, or during weeding. These moats twice the distance between two rice width and are 30—40 cm. deep.

When consumption fish are to be cultivated ats and dykes are prepared after the weeding. Sometimes a small pond n.) is dug at the intersection of the moats in the centre in order to provide the fish with shelter when the temperature of the watet is too high or when they are chased by predators. In some cases similar "ponds" are dug out in circular moats.

The following table gives different methods and rates of stocking.

Table III. Stocking rates for fish culture along with growing paddy.

Stocking time	Aim	Duration of Period	Remarks
Five days after planting until first weeding	Fry 2—3 or 3—5 cm. long.	3—4 weeks	Fry 2 weeks old.
Two days after first weeding	Fry 2—3 or 3—5 cm. long.	3—4 weeks	Field previously drained for 2 days. Fry of 10—50 days.
Some days after planting until second weeding	Consumption fish	6 weeks	Stocked with fry 2—3 cm. long
After second weeding	Consumption fish	8 weeks	Stocked with fish 5—8 or 8—11 cm.
extremely fertile paddy fields with good irrigation cultivation may take the following course:			
Some days after planting until flowering	Consumption fish	12 weeks	Stocked with fry 2—3 cm. long.
5 days after planting until second weeding	Consumption fish	6 weeks	Stocked with fry 2—3 cm. long.

The depth of the water is 2 cm. at the f planting and is gradually increased once k until it measures 5 cm. after 2 weeks. nsumption fish the depth is increased to after the second weeding.

After 3 weeks the fry is cropped. If ng is carried out mechanically and not by it starts 2 weeks after planting. Not all ater is run off, but only so much that about 1 cm. remains. In order not to harm the fish parts of the field are weeded alternately.

In the case of fry cultivation as indicated in No. III of the preceding table, the water in the circular moat is constantly changed. After weeding the same water level is restored.

When fry is being produced as indicated in Nos. I and II of the table, cropping takes

place during the second weeding. The rice will then be 4-5 weeks old calculated from the time of planting.

On the 3rd day after the second weeding the depth of the water is about 5 cm. It is raised once a week until a height of 15-20 cm. is reached 3 weeks after stocking. Afterwards, this level is maintained. About 3 weeks after stocking the moats are checked for depth. In case of an attack by mice the water level is increased until three internodia of the stalks are under the water, so as to inundate mice holes.

Raising of 15 days-old fry up to a size of 3—5 cm. takes place during a single period of 3—4weeks. But in regions where 30—40 days after planting weeding is carried out only once, the growth period is prolonged. This is done in East Garut (Wanaradja and Sadang).

Because management of a paddy field up to the time of the second weeding is fairly easy, fish culture along with rice is practised at distances of 1 km. from the villages. But after the second weeding, when the rice plants are high and it is not easy to observe the fish nor to walk on the dykes, this form of fish culture is restricted to areas nearer than 1 km. from the village or the road.

Experience has further shown that rentability is poor on complexes less than 5 ha., because of pests and diseases.

For cropping, the water is drained off more slowly than in the case of the other methods, to enable the fish to follow the stream and not to remain in the central part. For this reason draining usually begins during the night preceding cropping.

Generally, those fields are used where the ground is slightly sloping and fertile, the water contains organic substances and the living quarters of the owner are not too far away. It is important that men live among the fields used for this form of culture. Large uninhabited stretches should not be used.

In 1954 a new form of fish culture along with rice started in Surabaja and Lamongan, in paddy fields bordering brackish water ponds. These fields are situated on marly soils. At the beginning of the rainy season the fields are surrounded by heavy dykes with a base of 1 metre. Along the inside wide moats a measuring 1.5—3 m., and 50—70 cm About a week after planting of the rice the central part of the fields is covered by of water, small fry of the milkfish (*Chan Puntius* about 2 weeks old are introduc rate of 2,500—3,500 for both fish. The the water is gradually increased. The p growth begins in December and last months. The fish is cropped 2 weeks a paddy is harvested. So, when the p being harvested the field is still cover water. The yield—200—300 kg. ha—is s tory. At the moment this method cove 300 ha. only.

Instead of propagation of this culture in marginal brackish water pond salinity less than 8.00 % and extending the inland, extension work now proce the inland regions towards the coast. T method is readily accepted by the From older times this method was p outside Java (near Lake Ranau, S. S Some days after rice planting *Osteoc* introduced, but no moats are dug. C takes place at arbitrary times beginning months after stocking. Even when the completely harvested all fields still cont The farmer does not capture these fish away. He holds on to them, taking th gradually until the end of the dry seaso the ponds are emptied, So the total period takes 8—9 months. Exact c production and stocking rate are lacking can be stated here that this is the only of the cultivation of *Osteochilus* in padd that the total acreage involved measures situated at an altitude of 800 m., that th is clear, the soil sandy and that a heavy of *Ceratophyllum*, covered with epiph found in the ponds in the dry seaso dykes are 1 metre wide and strong.

Spawning of common carp takes Muntilan (Central Java.) In fields suit this purpose owing to the quality of the the water, holes of 1.0—1.5 m. diameter near the inlet, the dykes are strengthen the water in the central part measure Two or three female and one male spaw released in the holes. These are now with aquatic plants such as *Eichornia*. the fields had not been ploughed and h

nd, such plants are not necessary and ining paddy straw is deemed to be . If the spawning succeeds the fry is when 2 months old and 3—5 cm. long, ugh to be sold. If the spawners do not ggs after two or three days they are and the process is repeated after some en the field has been drained once

awning of common carp in order to ry takes place in regions north of a (Ngajlik). It is intended to use the ulture along with rice.

he spawning pond measures $5m^2$ with f 1 metre and is situated near the paddy be cultivated. Before use, the pond is in 5—7 days and *Eichornia* plants roots are inserted as a material to which will adhere. About one week afterwards ts are removed and the fry is used to addy fields, measuring about 10 ha. takes place 3 days after the planting of Afterwards, cultivation in between crops takes place after the field has rrowed. The growing period takes 4 nd the yield consists of fry 3—5 cm.

When the farmer considers the density of be too high, he often lets some of the gether with fish flow into an adjacent n doing so he will be guided by his l feelings.

n Tasikmalaja and Singaparna, *Helostoma* ned in paddy fields in between two rice A fertile field (rice yield 26 qu. ha.) ood supply of fresh water and situated e farmer's house is selected. After the as been harvested and the soil has been it, dykes (base 80 cm., height 50 cm.) structed. Inlet and outlet are constructed a way that the height of water is 30 cm. entral part. Both pipes are plugged with bre. In a 1 ha. paddy field 3 pairs of rs weighing 200 gm. each are used. The manured with 40—80 kg. horse manure. aw in the central part is cut when the ne week old. The period of growth r 40—50 days. One female spawner ,000 fry measuring 2 cm.

When the fry is 20 days old, 3-month old fry of *Osphronemus*, 2—3 cm, long, are added at a rate of 70—100 ha.

In Purwokerto only *Osphronemus* is spawned as second crop. The dykes are raised making the depth of the water in the centre 30—50 cm. The stocking rate is 150—200 fry measuring 2—3 cm. in length. The fry is fed with fine bran and white ants every day. The growing period lasts 2. months. The end product is fry measuring 5—8 cm.

Sometimes a nest is used instead of fry of *Osphronemus*. Two or three fields are needed for a single nest. Cultivation of fry of *Osteochilus* in Java in between two rice crops has been carried out for a long time in fields near centres of pond culture, such as Rantijapaku in the eastern part of West Java. After the fields have been prepared (dyked, ploughed, harrowed) they are manured with quickly decomposing plants, at a rate of 5 tons ha. Stocking takes takes place at place a rate of 200,000 fry measuring 1 cm. (5 days old) and 3,000 carp fry measuring 5—8 cm Every day the fish are fed with as much fine bran as is needed to cover the entire surface. The period of growth lasts for 40 days.

Raising fry of *Puntius* in between two crops along with rice, takes place iu Singaparna. Recently also in Purwokerto, as a result of propaganda by the Inland Fisheries Department and the wish of the farmers to grow this fish among their rice. The inlet and outlet must be securely screened with palm fibre. In the centre a moat 20 cm. deep and 30 cm. wide, is dug from inlet to outlet, in order to facilitate cropping.

In the centre the water is 10 cm. deep. Between 1 and 3 p.m., when the temperature is high, the water along the dykes is moved by the farmer with his feet or the water supply is increased for a couple of hours.

The fry is fed daily with fine bran. Two to three bowls are given in 1 ha., stocked with 150,000 fry along with rice or 200,000 fry when cultivated between two crops. Length of period: 25 days, Loss: 40% Yield: fry 2—3 cm. long.

Tilapia is grown between two rice crops and along with rice near Singaparna. Paddy fields with a layer of mud not less than 10 cm. in

thickness are used. Production is satisfactory. The method has spread rapidly. Begun at the end of the Japanese occupation it now occupies an area of 400 ha. In order to facilitate cropping, a small pond (1 m. square) is dug at the upper end of the central moat which is about 30 cm. deep, until a hard layer is reached.

When the fish is cropped they swim against the stream and gather in the small pond.

SPECIES OF FISH USED FOR IN PADDY FIELDS CULTURE

Official reports of the second half of the 19th century as well as other scientific publications show that the farmers regard the common carp as the fish most suitable for fish culture on paddy fields.

Government Agencies assumed responsibility for the spreading of this form of fish culture in order to ensure suitable local production of protein food for the population.

As the older reports mention "goldfish" only, *Cyprinus carpio* L. as well as *Carassius auratus* might have been included in that terminology. It is supposed that the name "gold-fish" relates to colour only and not the habitus of the fish. It is not impossible that *Carassius* was grown in paddy fields in earlier times and was as important as *Cyprinus* now, as is the case in Japan to day. It is not clear why *Carassius* is not used any more at present as this fish does not lag behind in rate of growth compared with the common carp.

It might be supposed that the brightly coloured *Carassius* is too conspicuous in clear water and will be preyed upon by birds to a large extent, thus causing heavy losses, and was therefore replaced by green varieties of *Cyprinus*.

In the second place the population in certain regions objects to orange-yellow carp on the grounds that consumption of this fish deteriorates the morals of the females. (reported by the Sub-station at Punteg, Java). When this Sub-station started the extension of yellow carp culture in 1924, the population was not willing to accept the fry for the above reason, and requested fry of a green colour, Therefore the selection of the Punten carp was initiated.

At the moment, the colour of t does not bother the population any long carp of various colours are being g paddy fields. The length of the fry stocked depends on the ultimate purpos culture.

In various regions large carp are in combination with fry, when carp is as a second crop between two rice crops

When tiny fry measuring abou in length are used, 5—10% by we fingerlings measuring 5—8 cm. are adde

When fry 5—8 or 9—12 cm. in fry are stocked, measuring 10—20 or 30- are added in quantities of about 5— weight. Why the farmers originally st stock their paddy fields with fish is un It is yet unsettled whether careful obse advice from abroad or just pure chan the cause. It is likewise unknown wh not the farmers were acquainted w natural environment of the commo (shallow water, soil without gravel or fairly high temperature, slowly running and were able to presume that padd might prove to be a suitable environm

Moreover, the carp is a quick and an easy and prolific spawner, most a to different temperatures, different so food and fluctuating concentrations of For these reasons this fish must have the attention of prospective farmers lon

Untoward features of the comm are that it is an easy prey for car fishes, and is rather susceptible t temperatures. For this latter reason t from paddy fields in the plains at low is unsatisfactory.

This might be the reason why beginning of the 20th century, farmers the vicinity of Djakarta began to grow *javanicus* (Blkr.) as second crop during of at least 3 months. However the ma may be the procurement of fry in th Propaganda by the Public Health Autho the effect that *Puntius* might clean th surface in the fields and thus lower the i of malaria, might also be one of the rea

these regions the culture of this fish spread and was restricted to marshy lds with suitable water. Ultimately rs became more inclined to the use of on carp. In other regions (Singarparna stern part of West Java) the culture of neets the need for fry of this fish to be onds in paddy fields. Here the ponds ived a mixed stocking since 1916. In lds fry measuring 2-3 cm. only are ese being subsequently transported in remote areas. Such nursing takes y in paddy fields situated not too far ponds.

Purwokerto (Central Java) *Puntius* is sed up to consumption stage. Procure- fry is rather difficult as the water too much silt for the spawning of the carp. Culture of *Puntius* up to con- n stage takes place in growing paddy about 2 months' time and starts after nd weeding.

or the past two years *Puntius* together *eocheilus* has been grown in the paddy ar Lake Ranau in Sumatra as a 50-50 These paddy fields depend entirely Stocking takes place in December, a s after the rice is planted. At the end ry period consumption fish is cropped. is case fish culture is continued until the August, long after the rice has been d.

n the vicinity of Jogjakarta a start was ith the cultivation of *Cyprinus* and up to consumption stage, along with ring the period between weeding and g. An equal mixture of fry measuring in length is used.

t was found that the rate of growth of nmon carp is about 150% of that of

n Redjang Kapahiang (Regency Bangka- V. Sumatra) an additional stocking of (33.3% by weight) is added to a stock- common carp.

Culture of *Osteochilus hasselti* (C.V.) fry s practised only in paddy fields in the ourhood of Lake Ranau (S. Sumatra). ew weeks old, are raised up to consump- tion stage. The fry are stocked some days after the rice is planted and are cropped 10 months later, at the end of the dry period when the field to be tilled and prepared for the next planting of rice. These paddy fields are situated at an altitude of over 900 m., the soil is sandy, they are never totally drained, the water is very clear and a dense vegetation of *Hydrilla* and *Ceratophyllum* develops after rice is harvested. Such an environment is most suitable for *Osteochilus*, feeding as it does on the periphyton of the leaves and stalks of aquatic vegetation.

In W. Java *Osteochilus* is grown only in between two rice growing periods in fields near fish culture centres. Culture takes one month (Singapore). Fry, 5 days old, are stocked in paddy fields previously manured with easily decomposing green manure. The initial stocking rate amounts to 100,000 *Osteochilus* ha., together with 5-8 cm. long carp fry (5% of the *Osteochilus* by weight). The soil where this type of culture is practised is sandy.

The demand for fry of *Helostoma*, to be grown in ponds mixed with other species had been increasing since 1910, and fry producers were no longer able to grow sufficient quantities. For this reason farmers near Tasikmalaja (eastern part of West Java) began to grow this fry in their paddy fields between two periods of one month. The fields are always manured in this case. The procedure is as follows:

In a field measuring 2 ha., 2 female sprawners weighing 250 gm. each are released, together with 3 males weighing 150 gm. each. The fry so produced, are fed daily with fine bran in quantities of half a handful to two handsful. Part of the bran is consumed directly and another (yet unknown) part will act as manure. When the fry are 10 days old, either young *Osteochilus* or common carp are added.

The number or *Helostoma* fry need for 2 ha. is usually 10,000 together with 10,000 *Osteochilus* 5 days old or 1,000—2,000 Common carp 10 days old. When the *Helostoma* is 20 days old, usually fry of *Osphronemus goramy* Lac., 2-3 cm. long (3 months) are added at a rate of 150-200 fry in two ha.

The following combination is often used in the eastern part of West Java.

Helostoma	35 %		*Tilapia*	50 %
Osteochilus	15 %		*Helostoma*	20 %
Cyprinus	15 %	or	*Osteochilus*	15 %
Puntius	35 %		*Puntius*	15 %
			Cyprinus	10 %

Since 1943 a marked change occurred in the usual stocking of ponds, owing to the introduction of *Tilapia mossambica* Peters. The demand for *Tilapia* fry increased still and so did the price. The change in stocking composition including *Tilapia* was accelerated by the decrease in the yield of the other species cultured so far. This decrease took place from the beginning of the Japanese occupation until the first years of Revolution. Owing to the increased demand and the ease of spawning in shallow, muddy water, farmers near Singaparna began in 1954, to spawn *Tilapia* in paddy fields with a mud layer of 20 cm. both along with rice until the second weeding and also between two periods of rice growing.

Eggs or fry of *Osphronemus goramy* are placed in paddy fields as a second crop., in Purworkerto (Central Java) only. Eggs are hatched into fry 3-5 cm., long and fry into fingerlings 8-11 cm. long. They are sold to other regions of Central Java end grown until until consumption stage in small farmyard ponds. The "second crop" method takes about 5 months, the stocking rate is 4-5 thousand fish measuring 4-5 cm. Eggs are stocked at a rate of 5-10 nests/ha.

An attempt to use *Trichogaster pectoralis* (Regan) as additional stocking material in the culture of common carp as a second crop, for 50 days, was not successful. The stocking rate was 10% of the weight of the carp. The average addition in weight of the *Trichogaster* amounted to only 15 % of the stocking weight, that of the Common carp to 400.

BIOTA FROM PADDY FIELDS AND THEIR INFLUENCE

Little information on the biota of paddy fields has been published so far *West*, 1902; *Fritsch*, 1907; *Bernhard*, 1908-1909; *Woloszynska* 1912; *Van Oye*, 1921. Based on the data of *Bernhard*, ecological investigations concerning the most important groups were carried out.

As a result of the changing ecological conditions, Myxophyceae are abundant during the first state, later on Desmidiacae, f by a mixture of both groups and in t stage Myxophyceae once more domin plankton.

Blue-green algae appear before t plants and other aquatic vegetation sh water. Later on, when the rice ha harvested and the sun rays can reach the these algae reappear.

Chlorophyceae are also often enco mainly on more or less obligosaprobi (*Buschkiel, 1938*), particularly, those th been under irrigation for a long time, an blue-green algae have begun to rot. I Diatomeae also are often found. Und circumstances both groups of algae are tant oxygenators and they will furni water with oxygen from top to bottom.

It should be understood that not o algal flora but also the micro-fauna sh taken into account. The totality of thi gical evidence is to be correlated with teristics of the crop, the soil, the water climate, the tillage of the soil and other t features of the industry. Only in t biological evidence can be applied with r efficiency, and the study of micro-orga paddy fields may not only be of import fish culture but also for the rice cultu fruitful co-operation between agrono limnology might develop. Limnology add materially to the solution of proble cerning metabolic changes in paddy fiel

The above bio-ecologic aspect, from the point of view of fisheries and ture may be summarized as follows:

"Measures should be taken establishment of algal successions e maximal oxygenation of the biotope, and unhampered conversion of food and yields. Which algal succession will ul fulfill these requirements must be elucid long-term research" (*Buschkiel* 1938).

In 93 % of all juvenile waters, in paddy fields, blue-green algae are foun optimal temperature for blue-green a above 20°, which is about the usual tem for paddy fields.

he occurrence of blue-green algae in mbers and of many species in paddy an indication of fertility. But better into specific differences between the is species is needed. Still it should not tten that great caution is needed before algae can be singled out as indicators in tural practice.

he paddy field-fish ponds of South g (Bodjong Lao), for example are ly fertile. The soil is fertile and the ven more so, as it contains much calcium anic substances drained from neighbour- ges and from parts of the city of Ban- This inflowing water is rich in Chirono- Oligochaetae and blue-green algae. The of the water is entirely or partly covered *ena sanguinea* Ehrb, sometimes occurring dense layers that the fish breeders dare k their pond with fry, for fear of sub- losses. Thus, although, *Euglena sangui-* rb. might seem to be an indicator for ertility, it can actually interfere drasti- ith fish culture, making the water thus oductive.

The water of ponds further down stream andung is coloured green by a water of Chlorococcales, indicators of an eutro- nvironment, and has a high content of orus and lime. These ponds are also Rotatoria, Infusoria, Crustaceae, diatoms ue-green algae, which serve as food for p fry. This is one of the reasons why fields situated near villages are stocked arp fry. If a pond or paddy field is rich organisms mentioned above, it will like- ontain Chironomidae and Oligochaetae, ing on such algae as *Aphanizomenon* and blue-greens, either living or in various of decay. These animals serve as food common carp is not limited to certain c kinds of food, but takes those types of l food most plentifully available, Hence t contents of carp sampled at the end of iny season (April) differ from those ed in July (dry period).

M. Sachlan and I. Zahir (1942), investi- the biota of two paddy fields behind the atory of Inland Fisheries at Bogor, Indo- during several months. They arrived at llowing conclusions:

1. One day after the fields had been irrigated snails, aquatic insects (*Micronecta quadristrigata*) and skaters (Gerridae) can be found.

2. Four days leter 75% of the soil was covered by a thin layer of greenish-brown diatoms (*Navicula, Suriella*) As soon as the sun rose this layer showed the greyish colour of the numerous oxygen bubbles, produced by photosynthesis which supersaturated the water. This layer, mainly consisting of *Navicula*, later covered the entire bottom. Chemical data of the water were: O_2—25—30 mgl.; CO_2—4-7 mgl.; pH—7.2-3.0; and temperature 39° C.

3. The water did not contain as many organisms as the soil, where plenty of *phora*, *Vaucheria* and *Kirchneriella* were found. In the water were seen: Oscillatoria, Protococcales, *Spirogyra Euglena* and Desmidiaceae. Animals were crabs (*Paratelphusa*) and frogs.

The difference between the algal succesion is probably caused by topographical differences.

Among the submerged Phanerogams which might be used as an indicator of the fertility of the soil and the water is, *Hydrilla verticillata* Presl. Its occurrence as well as its growth indicate the trophic state of its habitat. In oligotrophic water the habitus is poor and spare, the leaves are few and lean, but in eutrophic waters the shoots and the leaves are numerous. In eutrophic paddy fields where sunlight cannot penetrate far and also where the water is flowing rapidly, the poor growth, known in taxonomy as "*fluitans*" is often encountered.

Another plant indicating the fertility of the water is *Cerotophyllum demersum* L., to be distinguished from the less important *C. submersum* L. by the spines on the fruits. When one or more important factors governing plant growth are deficient, the leaves of this plant are scarce and the habitus poor. In calcium-deficient paddy fields (those on old lateritic soil) *Ceratophyllum* is rather soft to the touch.

Both plants often occur together in large quantities in eutrophic waters and form the substrate for periphytic diatoms and other algae. With these algae many animals such as Protozoa, Rotatoria, worms, Chironomides and other insect larvae are found, together with non-planktonic Crustaceans and bacteria.

Such waters are most suitable for the cultivation of periphyton-feeding species of fish, for instance *Osteochilus hasselti* (C.V.) as is the case in the vicinity of Lake Ranau (South Sumatra).

Both these submerged plants can be used as indicators, and they are also most important in the total nutrient cycle in fish ponds and paddy fields.

No conclusive experiments concerning the relationships between the yield of fish and the occurrence of various aquatic plants have been carried out. Individual differences between various species of plants might be investigated using different species of fish at different periods of their growth. The same fish species might be hampered in its growth as very small fry by too luxurious growth of plants. This might be true of a fish which is herbivorous in the fingerling stage and carnivorous later on.

On paddy fields with a thin layer of mud, situated at altitudes over 900 m., *Blyxa* is often found. On those under 700 m., in regions where the dry period is not very severe *Ottelia* is often found. Presence of these two totally submerged plants and of *Najas* indicate less fertile fields.

On the surface of paddy fields of at least mesotrophic fertility are found:

Salvinia natans All., *Spirodela polyrrhiza* Sch., *Lemna paucicostata* Heg., *Azolla pinnata* R. Br., *Pistia stratiotes* L.

Pistia and *Salvinia* often cover the entire surface, mainly when paddy fields are being stocked with fry during the second or third period (beginning of the dry period, May or June). In such cases they must be removed as they might interfere with the growth of the fish. Another harmful plant is the aquatic fern, *Marsilia crenata* Presl., (up to an altitude of 900 m.) mainly during March-November, in the case of stocking with fry. Although *Azolla*, *Lemna* and *Spirodela* usually cover the entire surface as well, they are not consid harmful. They are even often used as f ponds stocked with *Osphronemus* and *He*

Among the emergent plants gr the middle of the paddy fields, *M vaginalis* Presl., and *Limnocharis flava* H well as *Jussieua repens* L. growing a dykes are considered to indicate fields for fish culture. In the central part of t *Monochoria* usually appears first, follo *Limnocharis*, a plant capable of rapid and apt to cover entire fields. Often t to be cut in order to clear the surface. decompose easily they make suitabl manure.

On the other hand such plants as *odoratus* L., *C. eragrostis* Vahl., *C. elatus Fimbristylis miliaceae* Vahl., indicate un conditions for fish culture.

Investigations concerning the flora are almost entirely lacking. Acco Buschkiel (1938) anaerobic bacteria a important in the mud. But, on the oth this author concludes that aerobic bacte also find suitable conditions in the mud, the water often shows a high concentr oxygen, and conditions for photosynth diatoms and desmids are favourable.

Decomposition of vegetable rema paddy straw in previously drained pad is caused by the extremely rapid develo bacteria and leads to an increased produ fish. Action by the bacteria also ma highly polluted water entering the pad of South Bandung (Tegallega) suitable culture. Decomposition of organic su is most rapid in this water. The necessary for this process is generated photosynthesis of Cyanophyceae, Diato in a stage of advanced purification, Desm The farmer, knowing by experience th organisms need sunlight for photosy removes all floating vegetation from the of his pond. When in 1934 these were not taken, many fish died; H_2S was which harmed both animals and aerobic

Among the animals living in the organic substances and forming an i source of food for fish, limnicole Olig (Tubificidae) are important (A. Vaas va

Also, when paddy fields are drained Pulmonata are found, mainly on those where the layer of mud is thick, e.g.: *testudinaria* Lam., *Ampullaria ampullacea* *Planorbis (Helisoma)* spp., and *Paludina ra) javanica* Montf. These snails probably he fish in a direct or indirect way, as er (1949) holds in the case of those of aus *Cerithidea* for the cultivation of the h *(Chanos chanos)*.

No investigations concerning this harmful have been carried out so far. It might be at the snails, finding suitable conditions owing prolifically, will have a noxious ce in an indirect way, as they are ble feeders and also ingest decomposing substances. These snails are used as food and are gathered when the pond is d. For this reason they usually do not p into a serious pest.

The following insects are to be considered sts in fry ponds: *Belostoma indicum; is; Corixa, Dysticus; Libellia; Laccotrephes.*

Other insects often encountered on the e are: *Hydrometra, Gerris* and *Hydorus rnis* (Family Gyrinidae). Fishes are often d by the leech *Hirudo medicinalis*, and *Paratelphusa)* and *Monopterus albus* Zuiew, les in the dykes. In fry ponds frogs can mful, as they are apt to swallow the tiny o the farmer's practice of catching them e evening and selling them must be ered to be most useful.

Otters (*Lutra* sp. and *Ablamyx cineria* Ill.) rious pests. They live along the banks of vers and roam about in search of prey the early hours of the night. They are ated by smoking them out of their holes sulphur by means of a pair of bellows. imes such holes have many exits, in case all but one must be stopped before- This method is more efficient than the traps. Other pests are various snakes, as *Homalopsis buccata* (L), *Chersydrus latus* (Schneider) *Python reticulatus* Schn.

Herons, Kingfishers and Cormorants prey e fish in both ponds and paddy fields. cious fish and other fish acting as food titors with the cultivated species, are ful in paddy fields. For example:

Ophiocephalus striatus Bl., *Monopterus albus* Zuiew, *Ophiocephalus gachua* H.B., *Trichogaster trichopterus* (Pall), *Clarias batrachus* L., *Anabas testudinius* (Bl), *Lebistes reticulatus* Peters., *Aplocheilus javanicus* Blkr., *Puntius* sp. *Panchax panchax* (HB.), *Rasbora* sp.

In formed years, *Panchax* was often released in paddy fields to combat malaria.

MANURING AND INFLUENCE OF THE RICE ON THE FISH

Manuring of paddy fields for the sole purpose of fish culture is practised only in the case of spawning of *Helostoma* and in fry production of *Osteochilus*. The manuring of fields where *Helostoma* are to be spawned takes place as follows:

When the fry are one week old, easily decomposable plants are scattered on the surface of the water. Sometimes a mixture of plants and farmyard manure is used.

Plants often used for this purpose are the following:

Erythrina indica L., *Dysoxylum canlostachyum* Miq., *Erythrina crassifolia* Krds., *Dysoxylum ameoroides* Miq., *Leucaena glauca* Linn., *Hibiscus tiliaceus* Linn., *Crotalaria retusa* L., *Areca catechu* Linn., *Stachytarpheta indica* Dahl., *Ficus toxicaria* Linn., *Crewia paniculata* Roxb., *Tithonia diversifolia* Gray.

Experience has shown that fry raised on fields manured exclusively with farmyard manure cannot be transported over large distances. Mortality of fry raised on green manured fields is lower. A mixture of equal parts of both kinds of manure gives optimal results.

Depending on the fertility of the field the quantity of manure needed for 1 ha. is 40 - 80 kg. green manure or 20—40 kg. green manure and 10—20 kg. farmyard manure. Half of the total quantity of green manure is applied when the fry is 7 days old and the remainder is added in small amounts every third or fourth day. Farmyard manure is applied daily when the fry is 7 days old.

It is supposed that enough manure has been given when the water shows a blue-green colour, smells slightly of decomposition and the

fry do not swim along the dykes. If the water is black, a large number of common carp fry die, and the *Helostoma* fry do not dash towards the surface in order to gulp air with vertical movements but rise sluggishly with a slanting movement, the amount of manure applied must have been too large. In that case the pond must be flushed with clean water. The effect of manuring is most conspicuous. Fields used for production of fry without manure often show disappointing results and sometimes complete failures.

When fry of *Osteochilus* is raised on paddy fields green plants are usually the only kind of manure used. Five tons are needed for 1 ha. during a period of 40 days. The manure is applied before the field is filled with water. The use of manure is obligatory in this case, as the soil in the paddy fields used for this type of culture is sandy and the water clear and oligotrophic.

Manuring of fields used for fish culture between two rice crops takes place in Tjisaat (near Sukabumi). Farmyard manure is applied about 5 days after stocking with fry. About 7.5—10 tons are given for 1 ha. Manuring accelerates the growth of part of the fry (growing period of 30 days). Without manure 75% of the fry grow to a length of 2—3 cm., and 25% to a length of 3—5 cm. With manure, 40% of fry grows to a length of 2—3 cm., 40% to 3—5 cm. and 20% to 5—8 cm.

When fields used for fish culture between two rice crops are to be manured the cost of manuring should be calculated, except when manure can be obtained without any expense. But, because the next crop of paddy may also benefit by the previous application of manure the entire enterprise should be taken into account and not only the culture of fish.

When *Tilapia* is grown between two rice crops or along with rice, horse manure is given when easily available. In the first case, manure is applied on alternate days, and in the latter, every fourth day, in quantities of 1 ton/ha. Experience showed that manuring increased the production of fry.

Coarse rice bran is often applied on fields situated in the vicinity of places where rice is pounded and where harrowing is practised. It has not be on proved as yet that the fish grown in between two rice crops, benefit from th of manure but when the fish are grown with rice, the effect is evident; the fish quicker and more evenly.

In the method of fish cultivation as crop, manure is never applied as such plants cut off and thrown in to decompo increase the yield. The same applies paddy straw, either piled up or not. varieties of rice decompose quickly, oth not. In the case of easily decomposed the effect of manuring will be evid the first growing period. The experime Buahbatu near Bandung in 1933, were corroborated by the experience of the fa When the straw does not decompose quic effect will be felt during the second g period. The variety known as Djalan S decomposes slowly, Paddy Tjina and quickly.

Another form of manuring paddy where fish is grown as second crop is ap fields near the road or in the villages, public conveniences are constructed o dykes. No well planned manuring of where fish is grown along with rice ha carried out to date. Goor (1952) states th influence of double super-phosphate on fi rice is not reliable. Probably this state meant to apply to the rice only, and doubtful whether it applies to the fish.

In recent years, the farmers have r the disadvantages of those varieties of rice vegetative formation of shoots is heavy, Paddy Tjina. When this variety is closely the leaves touch, the sunlight is screened, the fish are hampered in their ment, and the yield is low. For this reas interspaces must be 40 cm. or larger on a field stocked with fish. It is yet un whether the method, advocated by the A tural Extension Service, to plant the regular rows in order to facilitate mec weeding has any influence on the fish.

YIELD AND RENTABILITY OF THE VA METHODS

'Yield' means the total quantity cropped and not the increase in weight a certain period.

d of "second crop" method per ha.
prinus carpio)

Consumption fish

a. Fields and water most fertile (South of Bandung); 3 periods of 40 days; yields of 200, 220 and 180 kg.

b. Fields and water moderately fertile; 2 periods of 50 days; yields of 130 and 160 kg.

c. Fields and water unfertile; a single periods of 90—120 days; yield of 100—120 kg.

d. Paddy fields in Radjang Lebong, Kapahiang, Bengkulu, South Sumatra. A single period of 6 months, or 2 of 3 months; Yield of 200—400 kg. of *Cyprinus* plus 100—150 kg. *Puntius*.

In a paddy field receiving heavily polluted water and constantly used as fishpond (Bodjong Loa, Bandung) the yield amounted to 3—4 quintals 30 days.

Production of fry

a. Field and water most fertile; stocked with fry of 14 days; 4 periods of 30 days; field 30,000; 40,000 and 20,000 fry 4—6 cm. long. In the case of the third and fourth period the yield of additionally stocked large carp (30—50 kg.) should be added.

b. Field and water fertile; 3 periods of 3—4 weeks; yield per period 25—40 thousand fry 2—3 cm. long.

h culture in between two rice crops.

Consumption fish

A single period of about 50 days, yield 40—60 kg.

Production of fry

a. Fry of *Cyprinus*, 14 days old. 1 or 2 periods totalling about 4 weeks.

Stock: fry 2—3 cm. long.

Yield per ha.:

a(i) One period: 20—30 thousand fry 3—5 cm. long.

a(ii) Two periods: 10–15 thousand fry 5—8 cm. long, weighing 3 g.

Yield of the additionally stocked large fish:

a(i): 30 kg. a(ii): 20 kg.

b. Fry of *Puntius*, 10 days old. A single period of 30 days.

Stock: fry 2—3 cm. (Purwokerto) long.

Yield: 80—100 thousand fry 2—3 cm. (Singaparna) long, and 20 thousand fry 3—5 cm. long.

c. Fry of *Osteochilus*, 5 days old. A single period of 40 days.

Stock: fry 5 days old.

Yield: 75—90 thousand fry 2—3 cm. long (eastern part of West Java).

d. Spawning of *Helostoma*. A single period of 40—50 days.

Yield: one million fry 1—2 cm. long, 30 days old.

e. Spawning of *Tilapia* (See Appendix I)

C. Fish culture along with rice

1. Production of fry, 14 days old

a. Fry of *Cyprinus*:

First period: 3—4 weeks (till first weeding).

Yield: 20—30 thousand fry 3—5 cm. long.

Second period: (in between both weedings).

Yield: 15—25 thousand fry 3—5 cm. long.

In other cases (Garut): a single period of 30—40 days.

Yield: 10 thousand fry 5—8 cm. long.

b. Fry of *Puntius*: A single period of 30 days. Fry 10 days old.

Yield: 60 thousand fry 2—3 cm. long (Singaparna).

In other cases (Purwokerto): stocked with 2—3 cm. long.

Yield: 20—30 thousand fry, 3—5 cm. long.

c. Spawning or raising of fry of *Tilapia*. (See Appendix II).

2. Consumption fish

a. *Cyprinus*. A single period of 60 days.
Yield: 50—70 kg./ha.

b. *Puntius*. A single period.
Yield: 40—60 kg./ha.

c. Mixture of *Cyprinus* and *Puntius* (equal numbers). Total yield: 60—110 kg./ha.

According to the Statistics Department of the Inland Fisheries Service, the total production of consumption fish in 1955 amounted to 9,160,000 kg. valued at Rp. 76,000,000 (@ Rp. 8.3/kg.). The highest prices were noted in West Java (Rp. 11/kg.) and W. Sumatra (Rps. 12.5/kg.), the lowest one in Jogjakarta (Rps. 4/kg.) and East Java (Rps. 5.5 kg.). West Java produced 7,000,000 kg., more than 3/4 of the total production in Indonesia. The total production of fry amounted to 3,256 million fry in 1955, mainly produced in West Java (Singaparna and Sukabumi) along with rice and between two rice crops. A large proportion of this fry was raised up to consumption state in paddy fields, the remainder in ponds.

The following examples are given of the cultivation of fry, advanced fry and consumption fish.

When 14-day old fry is to be raised up to the stage of consumption fish (about 15 cm. and 50—70 gm.), the following stages must be passed:

1. 900,000 fry 1 cm. long, 14 days old, grown in 1 ha. (about 100 bowls of 9,000 fry each) will need 14 ha. of paddy field. Stocking rates: 7 bowls per ha. paddy field. About 50% will be lost. The yield 14 ha. will be about 460,000 fry 3—5 cm. long.

2. Stocking rate of paddy fields used for advanced fry is 16,000/ha. of 3—5 cm. long fry. The yield will be 5—8 cm. long fry. When all the fry produced in stage 1 is to be stocked, 28 ha. of paddy fields will be needed. The percentage of loss will be 40%. The yield will amount to 269,000 of 5— long fry.

3. In order to use the entire c stage 2, 134 ha. paddy field needed, stocked at a rate of fish/ha. Loss, 30%. The yield be 180,000 consumption fish, (cm., 30 gram) representing weight of 5,400 kg.

It follows that the yield for 1 spawning pond is sufficient to stock about paddy field for nursing fry, about 28 ha. field for advanced fry, and about 134 ha. field for consumption fish.

A calculation of the profit derive fish culture on paddy fields is given following summary. This profit depends ratio between the selling price of the p and the expenses of the procurement of to be stocked. If this ratio is 3:1, the p 3 times.

The detailed data are given in Ap III.

It has been shown that overall ex of labour are maximal when fish is gr second crop. In both other methods the fa relations take the bigger share of the labo

Culture of Cyprinus

1. Second Crop

a) Very small fry

Paddy straw is cut of, scattered water or piled up. Circular or cross-mo constructed.

Stocking Rate : 60—100 thousand fry 2 old.

Period of growth: 3—4 weeks.

Yield : 31—50% of stock (fry 3— long).

Profit : 3—4 times.

A maximum of 3—4 growing perio season can be attained; at each successive the stocking rate is reduced by 10%. The carp, which grew rapidly during the per to a size of 5—8 cm., are used as add stock in the next following period.

The final (4th) period consists of t over stock of all previous periods only.

oderate sized fry

he paddy straw is not cut but knocked y. Moats are constructed. The stocking –16 thousand fry measuring 3—5 cm.

eriod : 40 days.
ield : 60% of stock (fry measuring 8—11 cm., 10 g.).
rofit : 3 times.
he young rice plants are removed. In thod the fry is stocked once in the g of the season.

Consumption fish

st period:

e rice straw is sometimes cut, sometimes cked down only.

cking rate: 1—2 thousand fish/ha. (8—11 = 10 g.).
Period : 50 days.
Yield : 75—80% of stock (fry measuring 15—20 cm. 8 g.).
Profit : 2—4 times.

ernatively:

cking rate: 2,000/ha. of fry measuring -8 cm. 4 g.).
Period : 50 days.
Yield : 70—80% of stock (fish measuring 14—18 cm., 70 g.).
Profit : —

cond period:

Both stocking rate and yield are ually 10% higher than in the first period. this case an additional stocking of larger h, at a rate of 5% of the primary stock, is ade.

Cultivation of consumption fish on paddy fields in Redjang Lebong.

Dykes are enlarged. No harrowing. ng in August. Cropping in February. o-do farmers grow fish only once, the armers twice.

Depth of the water : 50—100
Stocking rate : 3,000 carp fry (5—8 cm., 4 g.).
1,000 *Puntius* fry (3—5 cm., 1 g.).
Period : one of 6 months or 2 of 3 months.
Yield in 6 months : *Cyprinus* 30—40% of stock (25—30 cm., 200 g.).
Puntius 40—50% of stock (20—25 cm., 150 g.).
Profit : —

In the district Lebon 600 ha. is used in this way, in all other Districts a total of another 600 ha.

2. Fish Grown in between Two Rice Crops

a) Production of fry

Before stocking the field is ploughed and harrowed.

Stocking rate : 60—90 thousand/ha. of 1 cm. long, 10—15 day old fry, counted in bowls of 10,000.
Period : 1 month (In Tjisaat sometimes fine bran is given).
Yield : about 50% of the total stock (2—5 cm., 1—2 g.).
Profit : 3—5 times.
Additional stock : 2—3 thousand fry (5—8 cm.).
Yield of additional stock : 70% of stock (9—12 cm., 20 g.).

b) Fry measuring 3—5 cm. (2 g.)

The field is ploughed once. No harrowing.
Stocking rate : 16,000/ha.
Period : 1 month.
Yield : about 60% of stock (5—8 cm., 4 g.).
Additional stock : 1,000 fish (8—11 cm., 7 g.).
Yield of additional stock : 70% of stock (11—14 cm., 20—30 g.).
Profit : 3—5 times.

c) Consumption fish

Field not tilled. Paddy straw cut only. Very small fry are raised on fields far removed from the spawning ponds (about 2 hours walking).

Stocking rate : 500—2,000/ha. of fry (9—12 cm., 20 g.).
Period : 40—50 days.
Yield : 70% of stock (14—18 cm., 60 g.).
Sometimes additional stock : about 100 fish weighing 60 g. each.
Yield of additional stock : about 80% of stock (18—23 cm., 100 g.).
Profit : 2—4 times.

3 Along with Rice

a.i) Fry measuring 1 cm.

Stocked 5—7 days after planting of the rice.

Stocking rate : 50—90 thousand/ha.
Period : about 25 days till first weeding.
Yield : 40—50% of stock (2—4 cm., 1—2 g.).
Profit : 3—4 times.

a.ii) Second time small fry

Stocked after first weeding.

Stocking rate : 40—60 thousand/ha. fry (1 cm.).
Period : —
Yield : 40% of stock (2—5 cm., 1—2 g.).
Profit : 3 times.

b) **Fry measuring 2-5 cm.**

Stocked one week after planting, until second weeding.

Stocking rate : 6,000-8,000/ha. of fry (3-5 cm., 2 g.).
Period : 50 days.
Yield : 40-60% of stock (8-11 cm., 15 g.).
Profit : twice.

c) **Consumption fish**

Usually after second weeding until fi

Stocking rate : 1,000-2,000/ha. of cm., 4 g.).
Period : 80 days, if field is once.
— or —
Stocking rate : fish measuring 8 (10 g.).
Period : 60 days, if field is twice.
Yield : 50-80% of stock cm., 70-100 g.), period of 80 days. stock (15-20 cm., g.) for the perio days.
Profit : 4 times.

Culture of Puntius

1. Raising of Fry about 10 days old at Singaparna

Field ploughed once, harrowed once

Stocking rate : 160-200 thousand 1 cm. long fry; m in bowls of 4-6 th
Period : 30 days, fed twic with fine bran morning and even
Yield : —
Profit : at least 3 times.

In Purwokerto, where this meth introduced only recently, the following s rate is practised.

Stocking rate : 40-80 thousand/h cm. long fry.
Period : 1-1.5 month.
Yield : 40-50% of stock (1 g.); measured i of 2,000 — 2,50 additional food o ally given.
Profit : twice.

2. *Along with Rice*

a) **Fry production (Singaparna)**

Stocking 5 days after planting.
Stocking rate : 120-150 thousand/
Period : about 4 weeks, u weeding.

: 40-60% of stock (2-3 cm., 1 g.).
: almost 5 times.

arger Fry (Purwokerto)

) Stocking rate : 20-30 thousand fry (2-3 cm., 1 g.).
Period : 30 days.
Yield : 40-60 3-5 cm. (1½ g.)
Profit : twice.

) Between first and second weeding.
Stocking rate : 10-15,000/ha. of 3-5 cm. (1½ g.).
Period : 3 weeks.
Yield : about 60% of 5-8 cm., (2 g.).
Profit : twice.

Consumption fish

) Stocking after first weeding at Purwokerto; during the second weeding the fish stay in the moat.
Stocking rate : 2-3,500/ha. of 3-5 cm. (1½ g.).
Period : about 80 days till flowering.
Yield : 50-60% of 13-18 cm. (40 g.).
Profit : twice

i) Stocking after weeding; recently started in Jogjakarta.
Stocking rate : 2-3 thousand/ha. fry (5-8 cm., 3 g.).
Period : 60 days until flowering.
Yield : 50% of stock (11-12 cm.. 40-60 g.).
Profit : 3 times.

Mixed stocking of *Puntius* and common ong with rice at Jogjakarta; stocked 5 ter planting.

ocking rate, Carp : 1,000/ha. fry (5-8 cm., 4 g.).
Puntius : 1000/ha. fry (5-8 cm., 3 g.).
riod : 60 days.
eld Carp : 50% of stock (14-22 cm., 70-100 g.).
Puntius : 70% of stock (11-20 cm., 40-60 g.).
Profit : 4 to 8 times.

The growth of *Puntius* is usually slower than that of common carp, but its spawning may succeed in regions where common carp cannot be spawned. One of the bottle-necks of the extension of fish culture on paddy fields in Indonesia will be the procurement of fry. Only fry of *Puntius* larger than 3 cm. can be transported successfully.

Culture of Osteochilus.

1. Second Crop (production of fry)

So far this culture has been restricted to places near centres of pond culture, where manure is readily available. The soil must be sandy and the water supply plentiful. The average depth of water in the fields is about 30 cm. Quantities of manure needed: 6-8 tons green manure/ha. or 3-4 tons farmyard manure, to be given one week after stocking with fish.

Stocking rate : 150-20 thousand/ha. of 7 days old fry.
Period : about 30 days.
Yield : —
Profit : 4 times.

2. Along with Rice (continued as second crop)

Practised in Balik Bukit (South Sumatra) at an altitude of 900 m., on about 200 ha. The soil is sandy, the water clear, the paddy field cannot be totally drained, the depth of the water in the centre is 25 cm. Fry is stocked when the rice is 1 month of age. Cropping takes place at the end of the dry period, when the field must be tilled for the next planting period. The duration of the period of growth for the fish amounts to 6-7 months along with rice plus 3-4 months as second crop.

Stocking rate : about 25,000/ha. of 3-5 cm. long fry.
Period : 9-11 month.
Yield : 30% of stock (12-15 cm., 40 g.).
Profit : —

Culture of Tilapia mossambica Peters.

1. *In between two crops and along with rice.*

Stocking rate : 2,000/ha. of 4-7 cm. (3 g.) long fry.
Period : 35 days plus 15 days plus 15 days.

Yield, 1st Weeding : about 650 fish (10-12 cm.) = 18 kg. 27,000 fry (3-7 cm.) = 65 kg.
2nd Weeding : about 750 fish (10-12 cm.,) = 21 kg. 44,000 fry of (3-7 cm.) = 110 kg.
final : 30,000 fry (3-7 cm.) = 75 kg.
Profit : 40 times.

b) Stocking rate : 2,000/ha. of 8-12 cm. (20 g.)
Period : 20 days plus 20 days. (first weeding).
Yield, 1st Weeding : 762 fish of 12-14 cm. = 36 kg.
2nd Weeding : 21,000 fish of 3-7 cm. = 53 kg.
Profit : 4 times.

2. *Mixed stocking of common carp and Tilapia*

Stocking rate : 1,200 *Tilapia* (8-12 cm.) = 8 kg.
450 carp (8-12 cm.) = 6 kg.
Period : —
Yield : *Tilapia*–1,100 (12-14 cm.) = 39 kg. 14,000 (2-4 cm.) = 14 kg. Carp–300 of (13-16 cm.) = 20 kg.
Profit : 8 times.
Manuring : 1a.–7 public conveniences.
1b. – farmyard manure on alternate days.
2. – horse manure every third day.

Culture of Helostoma.

A fertile paddy field with sufficient water supply, situated near the village and where the finished product can easily be sold might be used for the spawning of *Helostoma* in between two rice crops as is done near Tasikmalaja.

Surface : 10 ha.
Manure : 4-8 hundred kg. green manure and 2-4 hundred kg. farmyard manure.
Period : 40-50 days.
Spawners : 30 pairs, each fish about 200 g.
Yield : about 100,000 fry measuring 1-2 cm. and 30 days.

When the *Helostoma* fry are 20 days old, 70-100 Goramy, 2-3 cm. in length, are added, and fed with fine bran.

Culture of Goramy

Production of fry on paddy fields near the village.

Depth of the waters : 40-50 cm.
Surface : 10 ha.
Stocking rate : 2,000 fry measur cm. (2 g.) or: 1 measuring 5-8 cm.
Period : 2 months; fed wit of white ants and n
Yield : fry measuring 5-8 8-11 cm.

Practical experience has shown profit may be stated as follows. During ing period of 30 days the profit amount times the costs of the fry stocked. D period of 50 days to 2-3 times. Ne labour is carried out by relations of the

In the case of paddy fields situat a town, where hired labour must carry work the cost of labour amounts to th gross profit of the first growing period. profit can only be attained during sub periods.

Expenses involved in fish cul between two rice crops are considered t to the costs of next rice crop.

When the income is calculated a centage of all expenses the following fig founded:

Cost of fry	:	30-50 %
Expenses	:	5-30 %
Profit	:	65-20 %

The customary rent for a pad amounts to 33.3 % of the expected yie instance in Singaparna the rent for a pa to be used for fish culture in between t crops is Rp. 75-150.—depending on the from the road or the village. Near about Rp. 400 are paid for 1 ha. of pad to be used for fish culture as second cro 40 days.

In region where the population ciently "fish-minded" the way fry is p and the product sold is as follows. percentage of the fish growers do not s product on the market as they do not the necessary equipment and are not ac with the customs of marketing. For thi they sell their fish to middlemen from place. Many middlemen selling fry n appointment with the farmer to buy the afterwards. Different ways of buying a ing are encountered. Often the price

by weight (consumption fish), or by measured in bowls (fry) after the fish en cropped. In some regions religion he selling of something that cannot be valued beforehand and the fish are sold or saucers, coconuts or sieves.

ut often the price is established before d has been cropped. It is obvious that ers must be experienced persons in this hey consider the stocking rate, the oil, and the habitus of those fish easily d in the field. When they do not furnish k themselves they have to rely on infor- of the farmer concerning the numbers d. They walk around on the dykes sing the water and soil and often churn nud in the neighbourhood of the inlet, in the case of consumption fish. When is heavily stocked the water is turbid dykes are pitted, a result of the active of the fish. The buyer knows that 9 and 10 in the morning the fish are most actively. Fry of equal length are red superior to fry of fluctuating length.

When the crop is sold as a whole the ften must crop the fish himself, otherwise nd seller co-operate. The farmer some- ays for the fry at the time of stocking n not until after the fish has been harves- ften the buyer will sell once more to iddlemen who go to the market. At the they meet other traders, who also do not ay straight away, but afterwards. Some make a living by contacting buyers and The trader who buys fry on the market to farmers in other regions and often special person to carry the fish. These are often prospective traders sometimes ered to trade themselves. In this way the ld to the farmer has passed 2 or 3 men and increased in price from 200 to Consumption fish is bought for the e of salting or other forms of preservation. y the traders work together in groups of nder one head, who is responsible for all al transactions.

NFLUENCE OF LAND TENURE SYSTEM N FISH CULTURE IN PADDY FIELDS

The desire to own land acts as a stimulus v fish on paddy fields. However on Java crease in available land suitable for fish culture lags behind the demand. Moreover, the area owned by a small group of capitalists increases rapidly owing to the rent system, and as a result, a large group of farmers will rent land from owners possessing excess land.

The present unsatisfactory situation found in West Java was explained by Vroon (1935) as follows. Eighty four per cent (84%) of all inhabitants make a living from agriculture, of which 14% have other sources of income and 70% depend entirely on agriculture. Only 42% of the farmers own the land themselves, and 5.79% of all land owners possess 31.76% of the total acreage suitable for agriculture.

Of the farms, 42% are smaller than 0.5 ha., 46% in between 0.5 and 2.67 ha., 10.4% in between 2.67 and 13.33 ha., and only 1.6% more than 13.33 ha. Hence about 50% of the farmers have such small holdings that there is not sufficient work on their land to occupy them the whole year round. Often the rent combined with the expenses for planting etc., exceeds the value of the crop, the more so when the fields are situated far from the farmers residence. Some data on rents customary in Tjiandjur are given below.

Classification of field	Yield of rice in quintals	Annual rent in quintals of rice
I	35—40	25—30
II	30	20
III	20	16
IV	18	14

The way the land is to be operated is not specified in the rent contract provided the rent is paid at harvesting time during the wet season.

In the Tjisaat (Sukabumi) Sub-district the lease-holder receives 20% of the yield of rice and is entitled to grow fish as second crop for 3 months and along with rice for 1 or 2 periods.

In Tjiparaj, where a few persons own most of the fields, these are managed by special overseers, who may lease out the fields on a share basis or on pre-arranged conditions, e.g. rent of 1 ha. will be about 11 qu. from yield of about 20 qu./ha. Taxes, seed and gratifications are paid by the farmer. The overseer receives 10% of the owner's share. Moreover the

leaseholder is bound to assist in the tillage of the overseer's paddy fields to an acreage of 20% of what he has rented.

Hiring land on a share basis is quite common. In some regions the leaseholder receives half or one third of the rice only, in other regions the second crops must be shared as well. Concerning seed, fry and taxes the contracts differ, sometimes the leaseholder pays for seed and fry and the owner pays the taxes, sometimes the leaseholder pays all.

Usually the leaseholder—mainly a man of weak economic position—is satisfied when his share of the rice crops covers his expenses. They try to reduce expenses as much as possible and, if possible, work their fields themselves with the aid of their families. They curb the expenses for procurement of fry and try to obtain a marketable crop quickly, and arrange that the crop is marketable in bulk in case of emergency. Fish culture fulfils these needs. For this reason fish culture spreads rapidly in regions near centres of pond culture where rents are high. Which of the three types is practised depends on the frequency of the rice cultivation. In case the farmer is unable to buy the necessary fry, the owner or the overseer may do so and the final crop will be shared by both parties. In such cases the owner will receive one third.

Experienced fish growers dare to cede their entire crop of rice to the landowner, provided they will be able to grow fish as second crop, in between two rice crops and along with paddy, for two periods. In regions such as the Bandung area, where fish culture on paddy fields is well established, rents are paid in cash, calculated per period. Near Bandung the rent of 1 ha. paddy field to be used for fish culture as second crop during 5 months in 3 periods of 40 days, amounts to Rp. 250—300 per period. If the owner constructs the dykes, the rent will be Rp. 400—500. In the vicinity of Rantjaekek, for 2 periods of 50 days, second crop method, the rent is Rs. 150, when the owner constructs the dykes. On less fertile paddy fields, where fish is grown for a single period of 3 months, the rent will be Rp. 100/ha. In Singaparna, the rent for 1 ha., where fish is grown along with rice or between two crops, amounts to Rp. 75—150. In the Wa area, the rent for the entire growing pe between two crops of rice, 1 period of and 1 of 60 days, amounts to Rp. 300—6

When fish is grown between t crops, sometimes the leaseholder stoo later crops the field which is given back owner at the time of replanting with ric

Quite often conditions of lease a severe for the farmers. Why do th submit to them? Here psychological concerning the farmer's social standing village, come into play and he also fee independent. This desire for independ encountered outside Indonesia as well the reason why the farmer prefers to w his own environment with his own fam relations in his own way and to make profit. Moreover, the owner wants th even if the profit is going to be small.

An experiment carried out in S (Tjiandjur area) in 1948 showed that the of fish as a second crop after the harves rice gives the highest profit. The influ a previous crop was investigated, as well hours of labour and the expenses involve relative advantages of the following co tions were examined: rice and rice (3 cr years); rice and fish; rice and sweet pota

In connection with hygienic m taken in the Tjiandjur area, three d cases of rice and fish culture were co Yield of a paddy field stocked with f treated according to the customary way farmers (Case B) was compared with th obtained when the technique advocated Public Health Department was employed C and D). Plot in Case B irrigated in a trary way; the depth of the water was 10- After the rice was harvested the stra immediately cut and piled up. Dense vegetation was cut as well.

In Plots belonging to case C, th was 20 cm. deep, the straw was cut as w in the B-Plots, the vegetation was cut surface of the water was kept clean. Plots were treated in the same way others but the depth of the water was

id vegetation were cut and discarded.
ving periods were as follows:
anuary to 23 June : fish.
)ecember to 8 May: sweet potato.
5 March to 20 June : East monsoon paddy.

The results are given in the following table:

Effects of various crop combinations on the yield of rice.

uct	Labour by relations in man-hours	Other forms of labour in man-hours	Hired labour in man-hours	Hired labour man-hours	Total in man-hours	Yield in quintals per ha.
(A)	455	70	303	—	828	50.9
(B)	267	90	—	—	357	2.1
(C)	370	103	—	—	473	3.2
(D)	451	97	—	—	548	2.3
(E)	575	316	390	30	1,281 (plus 30 man-hours for animals engaged)	10.3

t follows that cultivation of fish does rease the expenses, particularly when alized that only half of the paddy field r exploitation. The period of exploita- the paddy field for fish culture does ncide with the period when the soil is illed for the planting of paddy during ay season.

A calculation of the expenses and profit, into account the respective prices of weet potato and fish, showed that the ation of rice and fish with sufficient supply (B and C) yields the highest So it will be evident that the combina- rice and fish will be the most suitable regions where the water supply is te the whole year round.

DEMANDS OF FISH AND RICE ON WATER SUPPLY

No exact data are available on the ties of water needed for the growth of paddy fields. Investigations are lacking ne data given here are derived from xperience. A large percentage of the fields used for fish culture are situated ions outside the area irrigated by the Irrigation Department. Here irrigation is arranged locally, by mutual consent of all interested parties and in accordance with local customs.

Usually the quantity of water needed for fish culture is considered to be equal to the amount needed for the rice (tillage of the soil and irrigation of the crop). Data on the needs of the rice fluctuate heavily. A paddy field in the lowlands stocked with fish will need 1—2 litre/sec./ha. However, the amount actually running through the fields is lower than the amount to be drawn from the main irrigation canal, as some water will be lost through leaking dykes. In Modjokerto (Reg. Surabaja) this amounts to 19% and at Tegal (Reg. Pekalongan) even to 50%. Probably these figures are true only for rice alone, as the same amount is usually stated for ordinary paddy fields. Practical experience goes to show that 2 litre/sec./ha., and even 1—1.5 litre/sec./ha. is sufficient for fish culture on a paddy field where the soil is not exceptionally loose, the dykes are firm and the field is properly guarded. The question is to maintain a sufficient height of the water layer on the fields.

The question now arises how much water is needed to fill the fields up to a height suitable for fish culture. At a rate of 2 litre/sec., from 5 to 6 days are needed to fill one ha. with a layer of 30 cm. in the centre.

Therefore large areas are not filled at once, but the individual fields are filled one after another according to their respective distances from the main irrigation canal. This way of filling is practised in the case of all three forms of fish culture. However cropping takes place in reversed order, the fields downstream first and those upstream afterwards. In this way the fields downstream can be filled with the water flowing out of those upstream, This practice also saves time for the filling of adjacent fields.

As experience has shown that the growth of the fish is hampered by fluctuations in the water level, the farmer tries to prevent such fluctuations as much as possible during the period of growth of fish in his fields. When the East Monsoon is exceptionally dry and the supply of irrigation water is almost exhausted, the farmer has to take care of his field even during the night. Extremely dirty water must be passed through a sedimentation tank if it is to be used for fry.

When, during the middle of the dry period, the water in the most is insufficient the management is as follows: during the day the fields with small fry receive as much water as possible and towards the night they are almost filled to maximum capacity. During this period the outflow is reduced. During the night all water is used to fill the other fields and in the morning the outlet is once more reduced.

It has been shown that tilling the soil of an irrigated paddy fields and the preparation for the next planting of rice are easier and less expensive than in the case of a dry field (fish as second crop allowing wet fallowing, versus dry second crop and dry fallowing). For this reason cropping operations are usually carried out at the same time as the tillage of the soil and water management is planned accordingly.

The irrigation water flowing constantly over the soil will influence its fertility. When fish has been grown as second crop on a field for many years in succession and th contains a high concentration of organ stances, the rice may show decrease formation and the yield may decrease. dingly, after 4 years of fish as second cro a dry second crop is grown or the fi fallow for one season. In some ca annually rotating quarter of the area i tionally not stocked with fish for fish rea

Fertile water not only influences and the rice but the soil as well. T becomes softer and the expenses for w decrease,

In the case where the fish is r as "catch-crop" the management of th is in accordance with the irrigation as indicated by local customs. Acco fish culture along with rice is pract the vicinity of Tjiandjur only until the weeding i.e. 2 months after the p of the rice After the second w the paddy fields here are totally until a rosette of adventitious roots h formed at the base of the shoots. drainage as much water as possible is out of the irrigation canals into th Then intermediate irrigation is applied i to keep the soil in wet condition, un rice is flowering on the 90th day. Dur next 10—15 days as much water as is supplied, and complete drainage immediately afterwards, as long as the does not yet protrude. When it does s is again supplied until the fruit is set, shows a green colour, about 29 days bef harvested. Final drainage follows at th

It follows that fish can only be until the second weeding on such field same applies for fish culture along with paddy fields manured heavily and pr used for fish culture as second crop. T of fish grown along with rice for 60 day second time of weeding is quite sufficien 150 kg./ha.) but the rice does not bear seed. At Buahbatu, near Bandung, the the paddy dropped to 20% of that of crops.

Now the question arises: does fish have any right to part of the water? regulations concerning the water s

fish ponds are among the objects in constant supply of water and entitled e in the irrigation water. The usual ns for crops needing water are valid fields stocked with fish.

is further stated that:

Minimal and optimal quantities of water needed by different crops are established by the Head of the Civil Administration in accordance with data furnished by the Ministry of Agriculture.

When the above mentioned data are lacking the ratio between the quantities of water available for second crops, sugar cane grown by the population, sugar cane grown by the factories and paddy fields stocked with fish, is 1 : 1.5 : 3 : 4. The regulations thus evaluate fish culture in paddy fields as second crop as high as rice cultivation. For both the other forms of fish culture the same rights are valid as for rice cultivation.

However, these regulations only concern irrigation by the official Irrigation Department. In the case of irrigation governed by the local village administration, all questions are discussed by the village council. This arrangement ensures quick decisions on matters of irrigation, canals and allotment of water.

ECTS OF THE FISH ON THE RICE

n this respect the activity of the farmer e considered as a unit. Cultivation of he main activity and that of fish should as an additional enterprise.

as Second Crop

Effects on the Expenses of Rice Cultivation

The time of cropping of fish immediately precedes the time of tillage of the soil for the next crop of paddy. If not, the soil hardens and harrowing becomes more difficult. In this way 50% of the expenses involved in harrowing can be saved.

The average number of hours necessary to harrow a paddy field where no fish has been grown before, is as follow:

Manpower 570 hr. Animals 182 hr.

For a field where fish has been grown:

Manpower 460 hr. Animals 50 hr.

These were the results of an experiment carried out by the Agricultural Extension Service in 1932, in collaboration with the Inland Fisheries Department.

b) *Effects on the Cost of Weeding*

Here a reduction can be noticed as well. According to the above publication the labour involved for the weeding of 1 ha. amounted to:
Without previous fish : Cultivation—400 hr.
With previous fish : Cultivation—270 hr.

c) *Effects on the yield of rice.* (see also Appendices IVa & b)

The result of the above mentioned experiment at Subandar gave the following figures: (Variety of rice: Back, planted in distances of 25 × 25 cm. between the plants).
Field used for rice and dry second crop : Yield–36.69 q./ha.
Field used for rice and fish : Yield–46.90 q./ha.

2. Fish in between Two Crops

As long as the cultivation of fish lasts the water in the fields is checked, and no parts become dry. The soil becomes soft and is easily converted to collodial form. The water also brings in some manure. The profit derived from the fish, attained without much capital, can be used to cover some of the expenses of rice cultivation. The mud layer will be thick, and consequently the cost of labour for planting and weeding will be low. Comparative data are still lacking, but although the influence can not yet be expressed in figures in a direct way, the farmers are well aware of it.

If a field is leased out for this method of fish culture, the owner stipulates in the contract that the field must be returned in a condition ready to be planted, and thus evades the expenses of harrowing.

3. Along with Rice

Hardly anything can be said on the direct effects of fry grown, either in the period until the first weeding or in the two periods until the second weeding. An indirect influence has

been shown, as the water supply is better checked by the farmer the mud will always be in good condition, and the soil will never be too hard. For this reason weeding will be easier and more thorough. According to information received a saving of 10-20% can be attained this way.

Another advantage of the constant supervision of the water supply, early in the morning and at night-fall, is that diseases and pests of the rice will be noted and control measures applied quickly. No fish is grown along with rice for the first 60 days in regions where the water is heavily polluted with organic substances (Bodjong Lao, near Bandung) because the rice will grow too much leaf, the ears will partly be empty and the ripening unequal. But in the period before the first weeding (4 weeks) no such effect is noticed.

Deterioration of the yield in rice caused by cultivation of consumption fish after the second weeding (60 days) was noticed in an experiment carried out at Buahbatu, near Bandung in 1935, and amounted to 15% (Variety of rice: Srimahi, distance 25 × 25 cm. soil: Bandung clay).

These fields were constantly used to raise fish as second crop before rice was grown (6 months, April–September) and during the period, beginning a few days after planting until the first weeding, fry was grown. A second experiment was carried out on the same plot to investigate further the influence of fish culture. Results are shown in Appendix IV (a).

In various regions of West Java the reactions of the rice to the fish were studied and the results were published by Hofstede and Ardiwinata (1950). The following table gives some data.

Effects of paddy-cum-fish-culture on the yield of rice. Yield in kg./sq.m. of wet rice.

Observation	Paddy	Paddy+fish	Increase
I	55	57	7.5
II	54	58	7.4
III	54	56	3.7
IV	35	37.2	6.3
V	62	65	4.8
VI	41	44	7.3
VII	42	45	7.1

As these figures indicated that a c tion of fish and rice increased the yield rice, further research was initiated at places on Java and Sumatra (Lampong, matra). Experiences at Jogjakarta, H and Malang did not show any obvious in those at Blitar I and S. Sumatra indi decrease. (Appendix IV (b). However, clusive data have been gathered to date search will be continued in various other factors than fish must be taken count. The habit of the common carp of c up the mud in search of food must be co to be a sort of tillage of the soil. The of vegetation on fields used to grow fr days after planting might be explained t Moreover the faeces of the carp might b dered as a sort of manure, but proba quantity is negligible. The dropping easily mineralised, except for the c remains of digested animals.

The desire of the farmers to comb culture and fish culture must be co of primary importance. In this case the takes better care of his fields, and end to obtain maximal yields.

Experience gathered by the Agri Extension Service shows that the in attention paid by the farmer when new of rice cultivation are introduced, usual better results than is probably due to the itself. The same can be said for paddy-c culture.

Observations in the field indica mice are a less serious pest on paddy field fish is grown among the rice.

It is possible that the higher wate maintained during the period between the weeding and the time the rice flowers, w also the period when the mice reprodu rapidly, floods the mice holes in the inhibits breeding of the mice and thus s an indirect control of the pest.

RELATIONSHIP BETWEEN FISH CUL IN PADDY FIELDS AND MALARI

In a region where specific regulat created for combating malaria, these have to be observed in fish culture in as they govern the irrigation canals and the

vater in the fields with the object of
ie larvae of the malarial mosquitoes.

the Regency of Tjiadjur the following
ns apply to the " second crop " method:

s and outlets must be thoroughly clean,
egetation is allowed in them and shore
tation must be cut short.

n fish is grown as a second crop all
raw must be cut, piled up and burnt
rice has been harvested and before the
ooded, either by irrigation water or by
vell water.

central part of the paddy field should
overed with at least 25 cm. of water and
noats with at least 30 cm. The height
ie dykes should be chosen accordingly.

dykes should reach 40 cm. over the
ace of the water and be devoid of any
tation. On the slope, the vegetation
uld be kept short.

walls of the irrigation canals should be
structed and maintained in such a way
the water does not overflow, and if
s do occur the outflowing water should
directed in such a manner that no holes
pits are formed.

Other regulations are applicable to fish
in between two rice crops and require
e tillage of the field for the next cultiva-
rice must fulfil certain specified condi-

Experience has shown that these regula-
vhen strictly adhered to, will have good
in non-technically irrigated areas. A
action of these fields lie fallow for some
after the harvest of the paddy. How-
addy fields lying fallow are usually not
d by the regulations, as there is no possi-
f the deposition of mosquito-eggs on dry
Nevertheless fields lying fallow usually
wet soil, due to rain or leakage, even in
ally irrigated fields or if no water is
for tillage or the soil for the next plant-
riod. On non-technically irrigated fields
those without technical irrigation, this
is even more apparent. Quite often
fields resemble marshes and the possibi-
f deposition of mosquito-eggs are many.

Between the extremes of a totally clean
e, completely devoid of any vegetation and a surface entirely covered by vegetation and resembling a meadow, the majority of the fields can be placed. If a field, observed from the margin, shows mainly water with occasional groups of plants there is little chance of *Anopheles aconitus* being found. But when mainly plants and hardly any water are seen the danger of malaria is apparent. Unfortunately, the regulations are far from lucid in this respect and incorrect interpretations of the term " unclean surface " are many. Low-grade fields workers entrusted with the supervision of paddy fields for malaria purposes are apt to interpret the regulations in a strict way and have often created difficulties. The provision that, " no vegetation should occur on the surface ", created the impression that a few grasses on a paddy field endanger the health of the population. Such field workers should be instructed beforehand by fishery personnel.

Until recently these fields workers directed their activities to fish culture as second crop and fishculture in between two rice crops only. However, fish culture along with rice raised the question whether the circular moats or cross-moats enlarged the danger of malaria as in these moats vegetation might grow more luxuriantly.

Hoeks (1935) investigated this question in the plains of Tjiandjur and his results have been published by Hofstede (1951). The data show that during a period of 90 days after the planting of the rice the following *Anopheles* species were found: *subpictus, vagus, barbirostrus, annularis* and *hyrcanus*. After 90 days, when the leaves are broader and a dense vegetation is found along the inside of the dykes, the dangerous *A. aconitus* is found in large numbers. Although these results must be corroborated by further research they are in accordance with the experience of fishery personnel that malaria-danger is negligible before the leaves of the rice close and reduce the penetration of sun-light. Fish culture along with rice will not increase malaria-danger during the first 90 days after planting.

Not only fish ponds but every open water should be checked for its danger in this respect. Incidence of malaria is about 40% *i.e.* 30 million Indonesians contract malaria each year. Mortality is estimated at 6-7% of the total mortality of the country (20/1,000 inhabitants). Thus 120,000 Indonesians die from malaria each

year. This figure is a minimum. These facts depict the economic loss involved. According to a statement by F.A.O. "The economic loss to the country through morbidity caused by malaria is conservatively estimated to be over 1.5 million rupiah annually". Furthermore, these facts illustrate the importance of the fight against malaria from the point of view public health as well as from that of national economy, and also their importance for fish culture in paddy fields.

OTHER ASPECTS

To increase fish production the area of paddy fields used for fish culture must also be increased. As was stated before, the total acreage of paddy fields used for fish culture in Indonesia amounted to 65,167 ha. in 1955 of which 52,210 ha. were in Java and Madura. The total area of paddy fields in Indonesia in 1955 was 3,430,290 ha. and 1,559,093 ha. in Java and Madura. So the paddy fields used for fish culture in Java and Madura amounted to a mere 2% of the entire acreage, or 5% of all irrigated fields (2 million ha.). Additional culture in irrigated field could be planned. In view of the success of the culture of *Chanos* and *Puntius* in the Surabaja and Lamongan area, the paddy fields near the coast might be included in the programme. Outside Java, the regions of West, North and South Sumatra, Celebes, Bali, Lombok and Sumbawa merit every attention.

The spreading of this form of fish culture means amelioration of the daily menu and of income (Saanin, 1955), increase of paddy production at a rate of 3.7—7.5% (Hofstede and Ardiniwinata, 1950) and an increase in income.

The history of this culture, mainly in West Java, has shown that the following factors are of primary importance: water, labour, economic situation, subsistence fisheries in open water, transport of fish to the relevant region and last not the least, the fishmindedness of the population. Not only technical problems but the wish of the farmer as well come into play. A case in point is the attitude of the farmers of Jogjakarta towards *Tilapia*. After only two years of intensive propaganda this species became popular. Moreover, fishery measures should always be combined with measures to increase the yield of the rice, as rice the principal crop. In view of the f desired in various circles to increase quency of rice cultivation in all are sufficient water, the growing of fish two rice crops and along with rice st best chances. The second crop metho become exceptional in the future. Grow well along with rice may be the only m plains where mechanical cultivation o practised. Perhaps, 2-3 crops of rice grown alternately with a single crop o is done in Arkansas.

Other factors influencing the re apart from satisfying the needs of the c are:

a. altitude and slope of the area,
b. suitability of soil and water,
c. competition with preserv products and fish caught i waters and in the sea,
d. possibilities of marketing,
e. difference between the yield and dry second crops,
f. effects on quantity and qualit rice, vegetative growth, nu seeds in the ear, weight of th percentage of breakage and c of husking (Saanin, 1956).

The following data, gathered in regions on the effects of fish culture cultivation are of interest:

1. Ripening takes place 1-2 earlier.
2. If the water is too fertile near fish is only grown along w until the second weeding. If tion is continued beyond thi the rice will grow too man and bear too few seeds.
3. Usually fish grown along w do not influence the plants, the variety of paddy is suit the type of soil (unawned v e.g. Tjina, are unsuitable fo soil, as they are apt to unless planted at distances of

On marshy paddy fields the yield of the rice is usually decreased by the fish.

No increase of breakage of the seeds during husking is noticed.

Possibility of growing fry of various ages and lengths is increased.

n regions where the culture was recently ed difficulties in the procurement of fry n encountered. In order to satisfy the nent for fish fry in such regions ng Stations should be created working g to well defined plans. The site of institute should be chosen so as to efficient transport of fry. The farmers be encouraged to establish spawning and the Inland Fisheries Department provide these centres with selected rs. In order to select the right of fish to grow in paddy fields the of fry obtainable from one pair of rs should be taken into account. gh common carp is usually preferred might be more suitable in places where ng of carp is inhibited by local conditions. carp might be used as additional stocking l in such cases. The economic and structure of the area must also be ered. If many villages are scattered in a region special measures of guarding d need not be taken.

Problems of fish culture in paddy fields sely connected with problems of rice tion, as the latter is the main enterprise. l varieties of rice should be chosen for ation with fish according to the quality and water. Nothing is known in this t; even the relationship between the soil ice as the only crop are unknown. ence has shown that a suitable variety dy will quickly lose its good qualities and to be replaced after four years. Some es are suitable for the dry seasons only ust be replaced by others during the wet

In regions with fishminded populations lowing problems await solution:

1. Optimal stocking rate within a certain period under certain conditions.
2. Ratio between *Puntius* and common carp in various regions where such a combination is practised.
3. Effects of manuring: whether green manure or farmyard manure should be applied after the field has been ploughed and hoed; what is the effect when fish is grown in between two rice crops; whether fertilisers should be applied after the field has been planted with rice.
4. Effects of artificial feeding on the growth of the fry of *Helostoma*, Goramy and *Puntius*.
5. Water requirements for fish culture in paddy fields on various types of soil. However, Goor (1952) holds that the problems of water does not arise in the case of culture of fish along with rice.

In large, sparsely populated, well irrigated plains, *Tilapia* might be grown as the only species. The soil should be well tilled, in order to create a layer of mud not less than 20 cm. thick. The size of the end product is unimportant as small fish are acceptable as consumption fish. At the moment the population is easily satisfied with small fish, probably in future bigger fish will be required. To date a tendency to consume fish even smaller than before is evident, the minimum size having dropped from 30 to 15 cm.

Experience has shown that fish grown along with rice in fields near the villages never decrease the yield of rice. This only happens on marshy fields. In paddy fields near villages the yield of the rice even shows a slight increase, perhaps mainly due to the attention paid by the farmer to the water supply, better control of weed, aeration of the mud owing to the movement of the fish, mineralisation of organic substances and the control of diseases and pests. Paddy fields situated far from the village will perhaps not show these advantages, as control will be less rigid and weeds will not be so easily noted. In order to obtain a complete picture of the importance of paddy fields as a source of protein food for the population, data on production of fish and other edible aquatic resources in such fields should be gathered regularly.

SUMMARY AND CONCLUSIONS

1. According to available information fish culture in paddy fields originated in the eastern part of West Java. The first written information appeared in 1860. The spread of this practice was caused by the feeling of safety created by suitable agrarian law, freedom of activity and, to a large extent, by the fishmindedness of the people and the geographical situation of the area far removed from centres of sea fisheries. The activities of civil servants, the Agricultural Extension Service and, since 1934, the Inland Fisheries Extension Service may be credited with the spread of the practice outside Java.

2. Of the total acreage of paddy fields in Indonesia, 35 million ha. in Java and 1.5 million ha. outside Java, about 10 to 25% of the irrigated paddy fields are suitable for fish culture.

3. According to the Central Office of Inland Fisheries about 52,000 ha. in Java and Madura, together with 13,000 ha. outside Java were used for fish culture in 1955, producing about 9 million kg. of consumption fish.

4. Fish culture in paddy fields may be divided into fish culture as second crop ('palawidja'), fish culture in between two rice crops ('panjelang') and paddy-cum-fish culture. The first form of fish culture is practised in paddy fields where rice is grown once a year, the second form in those where more crops annually are grown.

   Depending on the fertility of the soil and the water, the distance of the pond from a major irrigation canal, and on the socio-economic condition of the farmers, culture of fish as second crop is subdivided into 3 periods of 40 days, 2 periods of 50 days or a single period of about 3 months. In between two rice crops fish is grown for 1 or 2 months of 1 or 2 periods. This method dates back to the years immediately after World War I, When there was a substantial increase in rice cultivation. In the eastern parts of West Ja paddy-cum-fish culture met much older than the "panj method, but was originally pr for raising fry only, during the between the planting of the ri the first weeding. Subsequen were grown in the period betw first and the second weeding rice and consumption fish were in the final period between the weeding and the ripening of t However in Central and Ea only consumption fish have grown simultaneously with t since about 1930, owing to the of water and the needs for w the sugar cane fields. In the cu fish as a second crop as between two rice crops, part field is used to raise fingerling

5. The principal species used common carp (*Cyprius carpio* all varieties available, togeth *Puntius javanicus* (Blkr.) 'taw *Tilapia mossambica* Peters, 'm All three are being grown to fin stage as well as to consumption *Tilapia* was introduced aft Japanese occupation. Cult 'tawes' started near Purwoke a few years ago, owing to a s of fry of the common carp. culture of common carp and along with rice started only r However, culture of fry of between two rice crops or alon rice until the time of the first w was practised in the vici Singaparna (eastern part o Java) as early as 1920.

   Culture of *Osteochilus* (C.V.) 'nilem', to consumptio takes place in the neighbour Lake Ranau in South Su formerly along with rice only, also as a second crop. On Ja paddy fields situated in the vic 'nilem' ponds, 5-day old fry 'nilem' are sometimes grown b two rice crops. *Helostoma te* C.V., kissing goramy, 'tam

are spawned in paddy fields near Tasikmalaja in the eastern part of West Java, in the period between two rice crops, in order to obtain fry.

Trichogaster pectoralis (Regan) is unimportant as a second crop in Java. *Osphronemus goramy* Lac., goramy, is grown as a second crop near Purwokerto, mainly, fry 2-3 or 5-8 cm. in length are used. Sometimes goramy nests with eggs are placed in the paddy fields to hatch. At Tasikmalaja goramy is used only in combinaton with 'nilem' fry.

6. No elaborate investigations concerning the biota of Indonesian paddy fields ingested by fish have been carried out to date, neither have paddy fields been studied as ecological biotopes. Some incidental observations have been recorded by Bernhard, Oye, Woloszynska, Buschkiel, Vaas, Sachlan and Oven, *loc. cit.* Numbers of aquatic biota are apt to fluctuate heavily. It is evident that the growth of the fish is influenced by the aquatic vegetation of emergent and submerged plants, and also by the availability of Chironomides and Oligochaetes. Our knowledge concerning the mutual influence of various groups of aquatic animals and their importance for the growth of the fish leaves much to be desired. Diseases and pests of the fish are fairly well known.

7. Addition of stable manure, green manure or a combination of both manures for the sole purpose of fish culture in paddy fields is practised only in the case of the culture of *Helostoma temmincki* and fry of *Osteochilus hasselti*. In between two rice crops, stable manure, rice bran or both are mainly used for the benefit of the next crop of rice. The field in which fish are grown as a second crop is not intentionally fertilised, but up-rooted aquatic vegetation and paddy straw act as fertiliser.

8. Yield and rentability of each of the three methods is as follows:

a) Yield of second crop method, per season;

Consumption fish:

i) Fertile water (3 periods) about 600 kg./ha.

ii) Moderate water (2 periods) 300 kg./ha.

iii) Unfertile water (1 period) 100-200 hg./ha.

Fry: (4 periods) about 100-200 thousand fry measuring 4-6 cm., together with 50-100 kg. of large consumption fish, always stocked along with the fry.

b) Yield of fish culture in between two rice crops:

Consumption fish: (1 period) 40—60 kg./ha.

Carp fry: (1 or 2 periods) 40—60 thousand fry (3-5 cm. long), or 20—30 thousand fry (5—8 cm. long), together with 20—30 kg. of large consumption carp.

Puntius fry: (1 period) 80—100 thousand fry (2—3 cm. long) (Singaparna) or: about 20,000 fry (3—5 cm. long) (Purwokerto).

Osteochilus fry: (1 period) 75—90 thousand fry (2—3 cm. long).

Spawn of *Helostoma:* (1 period) 1 million fry (1—2 cm. long).

c) Paddy-cum-fish method:

Consumption fish: (1 period of 60 days)

Cyprinus	50—70 kg./ha.
Puntius	40—60 kg./ha.
Equal numbers of both	60—100 kg./ha.

9. Value of consumption fish: 9.16 million kg. = Rp. 76 million. The total number of fry raised on paddy fields in 1955 amounted to 3,200 million. The value of this fry cannot be easily worked out as price for fry varies, in time and space within wide limits. The relative efficiency of each method is illustrated by a comparison between the price of the stocking material and that of the end product.

Consumption fish: Value of end product = 2–4 times that of fry

Fingerlings fish: Value of end product = 3–5 times that of fry

The economics of the operations may be expressed as follows:

Price of fry : 30–50%
Expenses : 5—30%
Profit : 65—20%

10. In the important centres of fish culture in West Java rents for paddy fields are usually moderate for the smallholder; a relatively high rent stimulates the farmer to embark upon fish culture in one of its various forms.

11. Exact data on the quantity of water needed exclusively for fish culture on paddy fields are lacking. Irrigation authorities usually allot equal quantities to rice and fish. Further investigations on this subject are urgently needed.

12. The effect of fish culture on the rice is to be divided into the following items.

a) Fish as second crop:

i) The cost of preparing of the field for cultivation of rice decreases by about 30% of the amount needed to prepare the field when rice had been grown in the previous period.

ii) The costs of weeding are lower.

iii) The yield of rice increases.

b) Fish between two rice crops:

i) The fields benefit from longer fertilising action of the water.

ii) The income derived from the fish helps to meet the expenses necessary for the work on the paddy field.

iii) As a result of the constant irrigation the soil is softer and yields better to the plough.

c) Paddy-cum-fish culture:

i) Irrigation is better cont

ii) Aquatic weeds are controlled.

iii) The movements of t aerate the soil.

iv) Possibly organic substa better mineralised.

v) Diseases and pests of are more efficiently dea

vi) Probably the yield of t increases. Investigatio cerning this question in progress and do not y clear-cut results.

13. Where regulations concern cleaning of the surface of th fields in order to decrease the of malaria have been set u regulations should be strictly e

14. About 10% of the total area o fields, or 25% of the irrigat (about 5 million ha.), could b to the area used for fish cu present, mainly by the exte the methods of fish culture l two rice crops and paddy-c culture. Mechanical tillage soil might become important respect.

15. Procurement of fry will be am most important problems enco in extension. For this reason and *Tilapia* might come to the the near future.

16. Systematic investigations v needed as the size of the i increases.

17. In order to obtain a compre insight into the importance o fields as sources of animal comprehensive statistical info should be collected.

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Form of culture	Number	Length (cm.)	Total weight (kg.)	Price (Rps.)	(day)	Num-ber	Length (cm.)	Total weight (kg.)	% Loss	Value (Rps.)	and Mate-rial (Rps.)	Rent of Field (Rp.)	(Rp.)	
Common carp Raising of fry														Sukabumi. One family operates about ½ ha. Growing lasts until 1st weeding.
1st period (Sometimes)	60,000	1-2	6	200	21	30,000	3-5	60	50	600	20	—	380	
2nd period	10,000	3-5	20	200	25	5,000	8-11	50	50	400	20	—	180	
2nd period	40,000	1-2	4	120	21	20,000	3-5	50	50	400	20	—	260	Tjiandjur
2nd period	80,000	1-2	8	100	21	25,000	3-5	50	60	400	20	100	182	Singaparna
Raising of fry														Wanaradja. (East part of West Java). Paddy weeded only once, 30 days after planting.
1st period	15,000	2-3	8	75	25	10,000	5-8	50	30	400	20	—	305	
2nd period	2,000	5-8	10	80	60	1,500	12-15	70 ca.	20	420	40	—	300	
	or					2,000								
	1,500	8-11	15	120	60	1,200	14-17	70 ca.	15	420	40	—	260	
Consumption fish	1,500	5-8	7	75	60	860	13-20	70	40	420	20	—	325	Jogjakarta. Stocking after final weeding.
	2,000	5-8	8	100	60	1,400	14-20	85	30	510	20	—	390	
	2,500	5-8	10	125	60	1,450	12-22	90	40	540	20	—	395	
	3,000	5-8	12	150	60	1,600	14-20	84	45	566	20	—	396	
TAWES Raising of fry	100,000	½-1	6	200	25	60,000	2-3	45	40	600	20	100	280	Singaparna (Tasikmalaja), until 1st weeding only. Purwokorto, (mixed culture) until 1st weeding only.
Consumption fish (Carp and Tawes)	2,000	2-3	2	20	30	1,000	10-13	25	50	100	20	—	70	
	1,000	1-2	½	10	30	504	8-11	5	49	200	20	—	70	
Consumption fish	1,500	5-8	4	45	60	930	12-20	48	40	240	20	—	175	Jogjakarta. Stocked until final weeding.
	2,000	5-8	6	60	60	1,100	12-20	65	45	325	20	—	245	
	2,500	5-8	7	75	60	2,000	12-20	60	25	300	20	—	205	
	3,000	5-8	11	90	60	1,200	11-22	52	60	260	20	—	150	
Consumption fish [Carp (c) and Tawes (T)]	(C) 500	5-8	2	20	60	450	19-23	43	10	258	20	—	353	
	(T) 500	5-8	1	15	60	480	12-20	30	4	150				
	(C) 750	5-8	3	30	60	450	16-26	70	40	350	20	—	422	
	(T) 750	5-8	2	22	60	600	12-19	36	20	144				
	(C) 1,000	5-8	4	40	60	750	14-12	35	25	275	20	—	329	
	(T) 1,000	5-8	3	30	60	800	12-12	36	20	144				
	(C) 1,500	5-8	6	60	60	900	13-20	55	40	275	20	—	280	
	(T) 1,500	5-8	6	45	45	750	11-18	26	50	130				

APPENDIX I. Continued

TILAPIA 1st crop	2,000	4-7	6	36	35	27,000 fry 648 ad.	3-7 10-12½	80 18	—	195 (39 ad.	20	—		Circular moat 35×20 cm., farm yard, manure on alternate days. Fields near villages 5 periods of fish culture after planting of rice. Height of Water 3 cm. Mechanical weeding after 25 days, stocking of fish follows. At 2nd weeding (40 days) part of the crop is gathered. Then field drained for 2 days.
2nd crop					50 (15 after 1st period	14,000 fry 756 ad.	3-7 10-12	88 21		1,256 thousand fry	20	—	1,355	
3rd crop					20 (20 after 2nd period	31,000	3-7	32			20			
1st crop	2,000	8-12	40	200	21	1,524	12-24	72	20	360	20	—	140	25 days after planting fields weeded for 1st time, fish remain in moat, field then flooded to 7 cm. Variety of rice: Tjina. Field manured 3 days with horse manure once a day. Stocking as above. Depth of water in central part, 3cm. at first. Later increased to 5-7 cm. 4 conveniences constructed, and horse manure on alternate days. Irrigation water passes village. Circularmoat 35 cm. wide 20 cm. deep.
At 2nd cropping					20	42,000	3-7	34	—	504	20	—	484 624	

Form of culture	Number	Length (cm.)	Total weight (kg.)	Price (Rp.)	Period (days)	Number	Lenght (cm.)	Total weight (kg.)	Loss (%)	Value (Rp.)	Labour and material (Rp.)	Income (Rp.)	Further information
COMMON CARP													
Raising of Fry													Sukabumi: Labour costs include work on field. Field once hoed or ploughed and once harrowed. Depth of water 5-10 cm.
1st period	80,000	1-2	8	150	21-28	25,000	3-5	Ca70	Ca. 70	600	50	400	
2nd period	60,000	1-2	6	100	21-28	20,000	3-5	60	70	500	20	380	Field weeded again after 2nd period.
Raising of fry 1st period	40,000	2-3	20	200	21-28	16,000	3-8	70	60	600	20	380	Tjiamojur area: Depth of water 20 cm. Soil not tilled, straw knocked down, moat dug and dykes strengthened.
2nd period	3,000	5-8	10	120	30	2,200	10-14	60	25	420	20	280	Field hoed before stocking.
Other ways; Raising of fry													Field hoed twice and harrowed, vegetation worked under. Depth of water 20 cm.
1st period	5,000	3-5	10	100	40	3,500	8-12	60	30	420	20	280	
	3,000	4-8	12	120	40	2,400	12-14	60	20	420	20	280	Field hoed once before stocking.
2nd period	45,000-60,000	1-2	5	100	30	18,000-24,000	3-5	50-60	60	500	20	380	
Raising of fry 1st period	30,000	1-2	6	100	30	15,000	5-8	54	50	450	20	330	East of Garut: Fields ploughed or hoed once and harrowed. Depth of water 5 cm.
2nd period	2,000	5-8	8	80	40	15,000	12-14	60 Ca.	30	360	20	260	Depth of water 10 cm. Fry from 1st period.
or	1,500	8-11	15	100	40	1,200	14-16	60 Ca.	20	360	20	240	

APPENDIX II (continued)

Raising of fry	80,000 plus 400	1-2 5-8	8 1	100 12	28 28	24,000 320	3-5 8-12	60 4	70 20	360 40	20 (Rent 100)	140 40	Singaparna:
TAWES Raising of fry	120,000- 150,000	1	10	200- 250	25	80,000- 100,000	2-3	40	40	600- 750	20 (Rent 100)	280- 380	Singaparna: Fry of 1 cm. counted in saucers of 8,000 fry. Fry of 2-3 cm. counted in bowls of 2,000 fry.
Raising of fry	20,000	2-3	20	150	30	15,000	3-5	45	25	375	15	210	Purwokerto: Field once hoed and harrowed.
TILAPIA Raising of fry	15,000	3-8 3-8	30	180	30	24,000 900	3-9 10-12	— 24	— —	308 125	20	233	Singaparna: Field ploughed and harrowed. Fry. 50-60 days. Crop fish of 8 cm. Fry excluded. Depth of water 10 cm.
NILEM	300,000 plus 3,000 Carp	1 Ca. 5-8	5 14	200 60	40 —	90,000 2,000	2-3 10-14	90 40	70 30	750 200	320 —	230 200	Expenses of cropping Rps. 20. Fodder-bran added daily, repair of dykes, 10 ponds Rps. 100. Manured with vegetation 5,000 kg.= Rp. 200.

Form of Culture	Stock				Period (days)	Yield					Expenses		Income of operator (Rp.)
	Number	Length (cm.)	Weight (kg.)	Price (Rp.)		Number	Length (cm.)	Weight (kg.)	Loss %	Value of Crop	Labour and Material	Rent (Rp.)	
A. Fry Raising I	4,000	8-11	40	400	40	3,200	15-18	200	20	1,400	430	250	320
Fry Raising II	4,500	5-8	35	350	40	2,900	12-16	220	25-30	1,500	70	250	870
Fry Raising III	3,500	8-11	35	280	40	2,900	15-18	180	25	1,080	125	250	435
B. Fry Raising I	2,000	8-11	20	200	50	1,600	14-16	130	20	840	310	150	250
Fry Raisin II	2,500	8-11	25	250	50	2,000	14-16	160	20	1,050	70	150	650
	100		10	70									
	90		2.7	169									
C. Fry Raising I	1,500	12-15	30	300	90	1,300	20-25	200	15	1,300	325	100	775
or	1,500	12-15	30	200	120	1,200	25-30	240	20	1,680	325	100	1,055
al													

Details of Expenses	First Period			Second period		Third Period
	A	B	C	A	B	A
Construction & Repair of Dykes (Rp. 15 p.c., p.d.)	300	180	225			
Cutting of straw (Rp. 10 p.c., p.d.)	80	30	50	50	50	75
Cropping (Rp. 10 pc., p.d.)	20	20	20	20	20	30
Material	30	30	30			20
Total	430	310	325	70	70	125

Notes: (a) Field Area A. ca 0.5 ha. B. 1 ha. C. 2 ha.
Water depth 30 cm. 30-50 cm. 30-80 cm.
(b) During the third period, the price of fry drops to Rp, 6 per kg.

APPENDIX III Contd. Data on fish culture by Second Crop Method (Alternative Systems)

Form of Culture	Stock				Period (days)	Yield					Expenses		Income of operator (Rp.)
	Number	Length (cm.)	Weight (kg.)	Price (Rp.)		Number	Length (cm.)	Weight (kg.)	Loss (%)	Value of Crop	Labour and Material	Rent (Rp.)	
* D. Fry Raising	60,000	1-2	9	210	20-30	30,000	4-6	120	50	750	485	—	215
Fry Raising (A) I	80,000	1-2	12	280	20-30	40,000	4-6	160	50	1,000	—	—	465
Fry Raising II	80,000	1-2	12	280	20-30	40,000	4-6	160	50	750/1,000	10	—	530/710
Fry Raising III	40,000	1-2	6	140		20,000	4-5	80	50	500			275
	50,000	1-2	7.5	175	30	25,000	4-6	120	50	625	85		185
plus consumption fish	300	12-14	90	63		210	16-20	36	20	252			189
Fry Raising IV	40,000	1-2	6	140	30	20,000	3-5	70	50	400	—	—	260
plus consumption fish	400	12-14	12	84	30	320	16-20	40	20	280	—	—	196
or/Fry Raising III (a)	4-5,000	5-8	24-30	240-250	40	2,800	12-14	100/125	30	875	95		270/525
or/Fry Raising IV (a)	4-5,000	5-8	24-30	240-250	40	2,400-3,000	12-14	84 105	40	588 735	20		328 415
E. Fry Raising I	20,000	3-5	40	600	40	14,000	10-14	210	ca 30	1,750	430	300	525
plus consumption fish	100	16-20	10	70		98	20-24	25	ca 2	175			
Fry Raising II	20,000	3-5	40	600	40	15,000	9-12	220	ca 25	1,800	70	300	1,040
	100	16-20	10	70		98	20-24	40	ca 2	280			
Fry Raising III	15,000	3-5	20-30	375	40	9,000	8-11	70	ca 35	1,125	310	150	290

* Stock of 15-21 days

Note: One farmer operates 2 ponds of 0.5 ha. each, depth of water 15-20 cm. The owner operates the ponds himself and the expenses of cropping are paid by the buyer.

Fry raising continues into Third Period, if high prices are expected; if not, consumption fish are grown during third and fourth periods.

APPENDIX IV (a) Effects of fish culture along with rice on the yield of rice.

Locality: Buahbatu, Bandung. Soil: Bandung Clay. Variety of Rice: Back Planting distance: 25×25 cm.

No. of Field	Yield (a) (kg.)	wet weight (kg.)	dry weight (kg.)	Rice (kg.)	Bran (kg.)	Stalks (kg.)	No. of Field	Yield (a) (kg.)	wet weight (kg.)	dry weight (kg.)	Rice (kg.)	Bran (kg.)	Stalks (kg.)
3	149.0	35.0	25.8	15.9	8.5	1.4	4	149.0	36.0	25.0	15.2	8.3	1.5
5	133.9	34.4	20.4	11.2	7.9	1.3	6	124.9	31.2	23.8	13.5	8.5	1.8
8	145.4	36.3	23.6	14.0	8.1	1.5	7 (c)	152.9	38.2	26.5	14.6	10.3	1.6
9	127.9	31.9	22.9	13.5	8.0	1.4	10	152.4	38.1	26.1	16.2	8.2	1.7
11	133.6	33.9	23.6	13.6	8.5	1.5	12	155.4	38.8	25.7	14.5	9.4	1.8
14	153.4	38.3	26.0	16.4	8.0	1.6	13	136.9	34.2	25.9	14.9	9.5	1.5
15	133.4	33.3	23.3	14.3	7.1	1.6	16	164.4	41.1	27.8	17.8	8.2	1.8
17	100.9	25.2	19.0	11.1	6.8	1.1	18 (b)	130.9	32.7	26.5	16.1	8.8	1.6
20 (b)	136.9	34.2	22.5	12.3	8.5	1.7	19	141.4	35.3	23.3	13.5	8.3	1.4
25	144.5	35.0	26.4	16.0	8.9	1.5	24	143.0	32.0	25.0	16.5	6.9	1.6
27	160.6	41.0	29.0	17.6	9.9	1.5	26	170.0	42.0	31.5	19.9	9.9	1.7
29 (c)	151.9	37.9	24.5	12.6	10.2	1.7	28	144.6	36.1	26.0	15.0	9.0	2.0
31	151.6	37.9	28.5	17.6	9.3	1.6	30	138.6	34.6	26.5	16.4	8.6	1.5
32	129.6	32.4	25.0	14.0	9.5	1.5	33	136.6	34.1	24.5	15.5	7.7	1.3
34 (c)	172.9	43.2	34.5	18.5	13.4	2.6	35 (c)	132.5	33.2	23.4	11.5	10.0	1.8
36	158.6	39.6	29.8	18.8	9.2	1.8	37	154.4	38.6	26.8	16.8	8.4	1.6
38	146.4	36.6	28.1	17.9	8.7	1.5	39	118.9	39.7	23.7	15.0	7.3	1.4
40	168.9	42.2	29.1	17.2	9.9	2.0	41 (c)	168.4	42.1	26.7	12.8	11.9	2.0
		648.3	461.7	272.5	160.4	28.8			658.0	464.6	275.7	159.3	29.6

(a) Calculated, per 200 sq. m. stalked paddy

(b) Damaged by mice

(c) Yield reduced due to lodging

APPENDIX IV (b). Effects of culture of Common carp along with rice on the yield of rice (1955).

Location	Jogjakarta		Blitar I (Djiwut)		Blitar II (Pagergunung)		Malang (Bululawang)		Lampung I		Lampung II	
Soil	Alkaline volcanic lixiviate		Brown lixiviate		Brown lixiviate		Volcanic lixviate		Red lixiviate		Red lixiviate	
Variety of rice	Sigadis		Bongawan		Bongawan		Gadjah rawe		Sidjero		Tjere?	
Planting distance (cm.)	30 × 20		24 × 24		23 × 23		20 × 20		?		?	
Number of seedlings	3		2		4		2		?		?	
Manuring (after planting)	—		—		—		—		1 q./ha. double super-phosphate		1 q./ha. double super-phospate	
Age of rice (Days)												
1st weeding	26		26		26		40		37		30	
2nd weeding	58		—		—		—		80		60	
Age of rice when fish stocked	A —	B 30	A —	B 38	A —	B 50	A —	B 42	A —	B 10	A —	B 15
Average number shoots after tillering	14	13	2	2	1.3	1.2	2	2	21	21	21	20
Yield of rice*												
wet weight (kg.)	120.50	119.50	166.20	143.20	99.50	103.20	163.5	160.0	248.2	186.1	239.2	209.4
dry weight (kg.)	105.00	104.40	141.60	122.00	85.00	87.90	124.1	121.3	189.4	134.6	200.1	197.9
rice (kg.)	3.20	3.15	3.76	3.78	4.13	4.19	2.9	3.0	3.8	3.6	2.6	2.7
bran & stalks (kg.)	2.80	2.85	2.34	2.22	1.87	3.81	3.1	3.0	2.2	2.4	3.4	3.3
Breakage (%)	77.00	74.50	30.00	27.00	59.00	57.00	84.0	83.0	73.0	77.0	68.0	73.5

*Per 300 sq.m. A. Without fish B. With fish

PADDY-CUM-MILKFISH CULTURE, A CREATION FROM THE LOWLANDS OF THE SOLO RIVER

by

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ABSTRACT

An introduction of paddy-cum-milkfish *(Chanos chanos)* culture, a creation from the ands of the Solo river, is presented. This method has been started and developed by the ers of that region, in their efforts to increase their income, as their paddy fields do not any possibility for improvement.

These paddy-cum-milkfish ponds are created by digging circular moats inside the paddy s and are irrigated by a combination of rain and water from the irrigation canals scooped them by manual labour.

It is evident that from the technical, economical and social point of view, the prospects is kind of fish culture are favourable.

INTRODUCTION

On reading the word paddy fields fishery will think immediately about fish culture ich species as Common carp *(Cyprinus* , mudjair *(Tilapia mossambica)*, tawes *s javanicus)*, gouramy *(Osphronemus)* etc. and, whether the paddy-cum-fish method, the fish-as-second crop method, 'panjelang' (in between two rice crops) is used, will be of secondary impor- the main issue being that paddy fields d to increase the production of fish.

In 1955, 90.493 ha. of rice fields out of a 5,122,535 ha. for the whole of Indonesia sed for fish culture with a total yield of 47 kg. In 1940, out of 3,380,300 ha. fields in Java and Madura, 9,200 ha. were r fish culture after the harvesting of the which figure rose by 1950 to 77,200 ha. total yield of 7,709,603 kg.

The brackishwater ponds with their crops ndeng', shrimps, pawns and extraneous of fish, form another well known source uction.

According to the Head Office of the Fisheries Extension Service the total f brackishwater ponds in Indonesia amounted to 136,912 ha. in 1955, producing 30,411,117 kg. while figures for Java and Madura only amount to 96,356 ha. and 25,074,082 kg. respectively. In 1940 there were only 69,300 ha. milkfish ponds in Java and Madura.

Let us now introduce the paddy-cum-milkfish method to the reader. The name would suggest a sort of mixture between a paddy field and a *Chanos* pond. How might paddy fields and brackishwater ponds be mixed when hygienists working on malaria have advocated "a sharp separation between paddy fields and milkfish ponds" for a very long time and have based their hygienic projects on this idea and constructed their dykes accordingly.

In using the expression "paddy-cum-milkfish" method, the author does not want his fellow workers to unearth the hatchet buried so long ago and wield it once more in front of the malarialogists. It is certainly not the hatchet which has to be unearthed but it is the yet unexploited resources, many of which are yet to be found in Indonesia and specially in the lowlands of the Solo River, the region between the Kendeng Mountains in the South and the Northern Limestone Rocks in the North which is to be utilized.

Such unexploited resources have been utilized by the villagers in the eastern part of this region during the past two years. In this paper the author will try to acquaint his readers with the method, recently devised by the farmers of the deficit areas of rice production in the Regencies of Lamongan and Surabaya.

CLASSIFICATION OF BRACKISHWATER FISH PONDS

A definition of a paddy-cum-milkfish pond cannot be properly understood unless preceded by some information about its development and for this reason something about brackishwater fisheries must be related at this stage.

Brackishwater Ponds

According to the possibilities of irrigation and its genesis the ponds along the coast can be divided as follows, along a line from the sea inwards:

a) *Border ponds:* Ponds immediately coastal fringe, and not yet com formed by the process of sedimenta material eroded from further inland r They are used as trapping-ponds f swimming in at high tide.

b) *Shore ponds:* Ponds receiving su salt water, already fully develope specifically stocked with milkfish fr traneous fishes and shrimps are gath second crop.

c) *Middle section ponds:* Ponds similar t of section b), but receiving plenty o water from rivers and irrigation cana

d) *Inland ponds:* Senescent ponds, s far from the sea, receiving no or har sea water and fully dependent on th stocked with milkfish and tawes. S and extraneous fishes are unimportan

The areas of these groups ponds year 1943 are shown in the table below.

Brackishwater fish ponds in Indonesia in 1943.

Regency	Area of ponds in ha.			Total
	Border ponds	Shore ponds*	Inland ponds	
Surabaya	180	14,290	7,140	21,610
Sidoardjo	270	11,780	860	12,910
Total	450	26,070	8,000	34,520

*Group c) incorporated in group b).

We wish to draw special attention to the figures of the inland ponds in the Regency Surabaya, amounting to 7,422 ha. together with those for the Regency Lamongan. Irrigation of these inland ponds depends mainly on two rivers, the Solo River in the North and the River Lamongan in the South, and their tributaries.

Every rainy season the success of the farmer's enterprise depends largely on chance factors, because ill-timed floods are apt to eradicate all hope of a suitable crop of ri fish. This region has long been know deficit area and already long before Wor II such flooding did occur.

An annually recurring process ca steady increase of the soil on which the ponds are found, because these ponds, s as far as 15 to 25 km. from the sea, will a layer of sediments after each flood and dry period they are insufficiently irrigate

fish culture. The bottoms of these us raised are often planted with rice the yield is disappointing in most

though the ponds may be partly with rice, the farmers do not let rice on totally oust fisheries, the original of the ponds. In order to protect the inst the hazards of the floods and also nterest of fish culture, they dig out a cular moat when the rainy season is use the earth to strengthen the dykes. way the mixed culture of rice and fish o being in the lowlands along the Solo d here lies the reason for the difference t and origin of culture techniques in egions such as in Western Java and re.

um-milkfish ponds

has been pointed out above how process had been active in order to brackishwater fish ponds into paddy d how man, loathe to change old fishery tried to retard this process. But since any completely reversed their attitude ny paddy fields were converted into nce again, without however doing away e rice. How was this change brought According to the local Irrigation De- t 60,674 ha. of irrigated paddy fields are the Regencies Lamongan and Surabaya owlands along the Solo River.

The type of irrigation can be specified ws:

	Surface in ha.
Technical irrigation	5,978
Half-technical irrigation	27,210
Non-technical irrigation	27,486
	60,674

Contrary to the situation as it is found country many irrigation canals here are that the water cannot flow into the situated paddy fields and must be scooped em by manpower.

Because the water in the irrigation canals does not flow rapidly, the danger of damage to the rice crop at the time of heavy rains is apparent.

In many areas along the Solo River this situation is detrimental to rice cultivation. In cooperation with the Agricultural Extension Service, the local Civil Administration propagated rice cultivation on raised dams inside the paddy fields as is done in the cultivation of other crops such as maize, red pepper or sweet potato.

However, the extension of this form of dam cultivation as it was propagated here did not meet with much success, because the construction of the dams involved too much labour and expense and the yield was disappointing.

Reacting on the above situation of rice cultivation in inland ponds and also in view of the satisfactory results of double superphosphate fertilizer on rice as well as on the growth of *Puntius* and Milkfish in ponds, the farmers began to dig circular moats inside their paddy fields measuring 40 to 60 cm. in depth and 3 to 5 metres in breadth, at the beginning of the rainy season of the year 1954. The excavated earth was used to strengthen the dykes around the field as is done in the inland ponds in order to protect the rice and the fish against floods.

These paddy fields are irrigated in the same way as the inland brackishwater ponds, by a combination of rain and water from the irrigation canals scooped into them by manual labour.

This new form of paddy field used for rice culture and fish culture at the same time was given a number of new names by the Civil Authorities in their Reports.

In order to ensure a desirable uniformity the author suggested the name paddy-cum-milkfish pond, which name is in accordance with the origin as well as with the ultimate situation. The new name met with a good reception from all concerned.

Yield and acreage of the paddy-cum-milkfish ponds

How quickly this new enterprise, originated from the initiative and skill of the farmers themselves, took roots will be shown in the following table.

Total area of paddy-cum-milkfish ponds in ha.

	1954	1955	1956
Surabaja Regency	44	160.5	413.5
Lamongan Regency	104	147.3	645.0
Total:	148	307.8	1,058.5

Data on the yield of this form of cultivation have been published by the Head of the District Tjerme, M. SOEWANDI, in the *Pamong*, No. 2 of February 1956 issued by the Administration of the Regency Surabaja, which the present author has summarized, as shown below.

Experiment carried out by the farmer Alim Bau, on 2 ha. paddy fields situated at Kedungsambi (Village: Kedungsekar).

A. Income: exclusively rice, maximal crop: 40 quintals Rp. 2,200

Expenses:

a. ploughing	16 × Rp. 20	= Rp.	320
b. harrowing	6 × Rp. 20	= Rp.	120
c. winnowing	10 × Rp. 5	= Rp.	50
d. rice seedlings		= Rp.	100
e. planting and replanting		= Rp.	240
f. maintenance etc.		= Rp.	170
		Rp.	1,000

Nett profit Rp. 1,200

B. First year of paddy-cum-milkfish culture:

Income:

a. rice 40 quintals	Rp. 2,200
b. fish 7,40 quintals	Rp. 3,330
c. secondary crops	Rp. 270
Gross Income	Rp. 5,800

Expenses:

a. construction, digging		Rp.	2,000
b. ploughing	11 × Rp. 20	= Rp.	220
c. harrowing	4 × Rp. 20	= Rp.	80
d. winnowing	5 × Rp. 5	= Rp.	25
e. planting		Rp.	200
f. rice seedlings		Rp.	75
g. fry of milkfish		Rp.	700
h. guarding, maintenance etc.		Rp.	300
Total expenses:		Rp.	3,600
Nett profit:		Rp.	2,200

Whatever the reliability of the above figures, it follows that this new form of fish culture can be propagated straight away in the lowlands along the Solo River, as the r an extra crop of 370 kg. fish per ha., va Rp. 1,665. This method might well be e to the entire irrigated area of Lamong Surabaja, amounting to 60,674 ha., not the half-technical irrigated parts, t measuring 54,696 ha.

We have seen above that this seems most promising from the economi of view, let us now consider the techni social angles.

The soil of the plains along t River is margalitic soil from the northe of the Surabaja Regency to the eastern the East Java Province. There are blac hard to cultivate, retaining water ver which is an advantage from a fisheries view. Chemically they are rather poor, deficient in phosphorus. For this reaso soils react favourably on fertilisatio double superphosphate, when planted w and maize and also when used according method described with a mixture of rice, and *Puntius*. The heavy dyke used method is once constructed only and for use the moat has to be dug out each time the rains are expected.

Procurement of fry of Milkfis *Puntius* is not a problem in East Java, both are plentifully available, respectivel the coast and in the Solo River. It will task of the Fisheries Administration to i the capture operations and the distribu the fry.

From the social point of view it is that this new initiative, originating fr farmers themselves, shows a good perspe this region characterised by heavy rains the wet, and pronounced drought during season.

So, from the technical, economi social point of view the promises of this are favourable, only one item has to b dered, the procurement of the necessary needed in the beginning for the constru the dykes and moats. Short term cre duration of two to three years might solution of this problem.

It is most desirable that the pro credit for the farmers using this meth receive the serious attention of t authority.

FOOD-FISH FARMING IN THE UNITED STATES OF AMERICA

by

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INTRODUCTION

rowing food-fish in pond waters received ttention in the United States until . A previous attempt to establish farm s came in the late 19th century when t carp *(Cyprinus carpio* Linn.*)* were ced almost simultaneously from Japan stern Europe. That effort failed to ge carp culture. Americans did not common carp as a desired food. The owever, became numerous in American and lakes. Subsequently, they were ned as "rough-fish" by sport fishing throughout the United States. Tench *tinca* Linn.*)* were introduced in Califor- ut the same time but became neither a r a nuisance.

No important economic demand de- l until fishpond research at the Alabama ltural Experiment Station, Auburn, Ala. d national recognition between 1940 and . H. S. Swingle and his colleagues at the a Station experimented with some food everal species of catfish *(Ameiuridae)*, n carp, and Buffalo-fish *(Ichtiobus*, and *omatobus)*, but their outstanding success elf-perpetuating combination of Bluegill *is macrochirus* Raf.*)*, a forage sport fish, rgemouth bass (*Micropterus salmoides* a predaceous sport fish (Swingle and 1947).

Fortunately, from this research came pecific information which is now useful de in the chemistry, management, and tivity of waters for food fish. In fact, le (1954, 1956 a, b, c) has continued ous experiments at Auburn in an attempt velop profitable production of catfish, , carp and other fish. He is continuing st study of water and fish-feeding eco- as it applies to American taste and demand. In truth, the principal demand has been for *fishing for sport and relaxation*, as has been reported by Meehean (1951). On the other hand, a desire to produce a profitable food fish has been more real than is commonly realized. The Alabama Experiment Station and the U. S. Department of Agriculture Soil Conservation Service assist thousands of farm pond owners who produce sport fish as food at an acceptable cost per pound.

There is now a growing interest in food-fish culture in the United States (Division, 1955). It relates to proper land use and economics of land and water management.

FISH-RICE ROTATION ON CROPLAND

The peak production of rice in the United States was in 1954 when nearly [illegible] million acres (1 million hectares) were used for this crop. This acreage was reduced in 1956 about one-third to avoid an increase of rice grain surplus. There are, however, at least 4 million acres (over 1¼ million hectares) of food rice land in the States of Arkansas, Louisiana, Mississippi, Texas and California. Small acreages of rice are grown in South Carolina, Missouri and Tennessee. All rice soils are suitable for the impoundment of water for fish culture.

Rice production is highly mechanized in the United States. Two or three men can cultivate several hundred acres (a few hundred hectares). A rice field of 80 acres (32 hectares) is common; also a square mile, 640 acres (250 hectares), occurs often as a single field of rice. Of course there are smaller fields too.

American ricelands as well as other ricelands in the world, produce less when wet-land grasses, such as *Echinochloas* and *Panicums* compete with the rice for nutrients, space, and

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sunlight. When original prairieland and deciduous woodland are brought into rice production, yields of 100 bushels per acre (6,800 kilos per hectare) are common. In only 4 or 5 years the yield drops below the costs of operation, to a third, or fourth, or fifth of the original production. Rotation, 2 years in rice, followed by 2 years in pasture grass, soyabeans, or fallowing, is the usual treatment to assure profitable rice yields. When cattle prices are high, the rotation of rice with pasture is profitable. When cattle prices are low, the rice-cattle economy drops.

Many farmers now believe that flooding the rice land continuously for 1, 2 or 3 years is economically sound. The annual cost of flooding, $8 to $12 per acre, is about the same as that of fallow operations with machinery. Rice yields are high after 2 or 3 years of flooding, and grass and weed competitors are present but not serious.

Unfortunately, enough of these rice yields following fish or water-fallow have not been measured; nor has research analysis been applied to the effect of fish and water on soil fertility, soil, tilth, weed-seed destruction, and other significant facts. The Soil Conservation Service is now making these needed studies in Arkansas in co-operation with the University of Arkansas and the U.S. Department of Agriculture, Agricultural Research Service. We expect the studies to continue for at least 4 to 8 years, the period required for one or two 4-year rotations with rice and fish.

Grass and weed control by flooding requires a water depth of at least 12 inches, preferably 24. As rice growers began this new crop rotation, they discovered that native fish became established, grew rapidly, and offered economic possibilities. They learned what they could about fish culture but found that almost nothing was known about managing the fish which had grown best in their rice fields, big mouth buffalo, *Megastomatabus cyprinella* (Val.). A few farmers, the country agricultural agent and the Soil Conversation Service technician tried to develop a fish culture system in Lonoke County, Ark., where ricefields were first flooded extensively for growing fish about 1950. Fish production, however, remained uncertain. There were no hatcheries to produce stock. Bass, common carp, catfish, gre fish (*Lepomis cyanellus* Raf.), golden *(Notemigonus chrysoleucas* Mit.), shad *(D. cepedianum*, Les.), and other species the waters.

MANAGEMENT TECHNIQUES

In 1954 Swingle published a re commercial production of buffalofish. same year the Soil Conservation Service this report as a guide, began a series trials principally in Arkansas waters t dependable management techniques for ing fish. Progress to January 1957 can lined briefly:

1. **Finishing reservoirs.** A rice field is reflooded and stocked with fi after the rice grain is harvested with co machinery, ordinarily in October or No If the fish are to remain until marketed, them finishing reservoirs. We call them ponds if the size to be grown is inter between the hatchery and the finishing re Rice harvest begins in Louisiana a August. All of the organic matter exc grain is left on the field to supply nuitri the fish.

At present, stocking rates for b to be left 2 years before removal is 125 p For 1 year growth, 250 are stocked p Work is in progress in Arkansas and Alabama Agricultural Experiment Sta learn more favourable rates of stocking.

A depth of 18 or more inches i tained in the shallowest part of the fi reservoir. Maximum depth depends slope of the land, but is usually 3 or occasionally 5 feet. A harvesting pit inches deeper than bottom level of the r usually is dug at the drainage outlet.

About 10,000 acres (4,000 he formerly in rice, was stocked with Arkansas during 1955 and 1956. A few h acres were levelled, flooded and stocke fish in Mississippi, Louisiana, Tex California.

Another 10,000 to 12,000 acres cleared woodland mostly in Arkansas was flooded, and stocked with fish. The tre

bout 3 years, the water will be drained fish harvested, and the dead timber The new cropland will then be planted e. This is an economical way of clear- odland tracts for growing rice. The ill be left so that the area may be d for fish culture in succeeding rotations.

he size of a single field for fish-rice may be from 10 to 600 acres (4 to 240). Flooding as well as the harvesting keting of fish are easier in fields of 40 r less. Land-owners, however, are t to subdivide their rice fields into its. The cost of levees and drainage s ranges from $10 per acre for large $60 for small ones.

. **Fish hatcheries.** About 20 Arkansas have built their own fish hatcheries to fingerlings for stocking purposes. They y surplus to other farmers. Hatchery re small (0.25 to 1.0 acre each) and are 8 to 48 inches deep. Techniques are veloped for the production of buffaloes ally the bigmouth), red catfish (*Amei- bulosus marmoratus* Ho.), and largemouth The other two species of buffalofish, outh (*Ichtiobus bubalus* Raf.) and the uffalo (*Ichtiobus niger Raf.*), can also be ed successfully in farm hatcheries. The outh buffalo has a smaller head and sells ut 20 percent higher than the bigmouth ck buffaloes. The black buffalo probably well and grows as fast as the bigmouth. eem to grow somewhat faster than the outh. Until now, the bigmouth buffalo n used most widely.

The buffalofishes repress their own ing as do carp, when held in a crowded After danger of egg and fry loss due to cold is past, pairs are placed in fresh for spawning, Swingle (1953) reported Pacific Science Congress on the existence spawning inhibitor. Buffalo, carp, gold- iners and probably other species will not when this inhibiting factor is high.

There is evidence that a heavy population ayfish prevents bigmouth buffalo and shiners from laying eggs. In one in- golden shiners spawned soon after chemical treatment killed the crayfish in the same water in which they had failed to spawn. In another, buffaloes that were removed to water free of crayfish spawned within 48 hours. This was on June 15 which is 89 to 90 days after the usual earliest date of egg maturity.

There is considerable demand for channel catfish (*Ictalurus punctatus* Raf.) in Arkansas, Texas, California, and Mississippi, and for white catfish (*Ictalurus catus* Linn.) in California. Hatcheries can produce channel catfish but supply is uncertain and expensive. No one has yet developed a hatchery culture for white catfish.

Carp culture is well understood, but there is almost no demand for this fish.

3. The carrying capacity of fertile water appears to be about 500 pounds of buffalo per acre (500 kilos per hectare) and 300 to 400 pounds of common carp. This means, of course, an average annual yield of only 250 pounds of buffalo per acre (390 kilos per hectare) where they are left 2 years without transfer or reduction of numbers by partial harvest. Where systematic feeding is added to fertile water, 1,000 pounds of common carp were produced at Auburn. Under the same conditions 1,200 pounds of channel or red catfish (Swingle, 1956 b, c.) were produced.

Where nutrients in the water are low or only moderate, we recognize the need of artificial manuring. In America, commercial inorganic fertilizers are more economical than manures. We apply about 100 pounds per acre of 8-8-2 (N-P-K) as often as needed. The objectives are (1) production of a high yield of fish and (2) prevention of submerged aquatic weeds.

4. Market size fish. Americans demand relatively large fish for food. There is almost no market for buffaloes smaller than 2 pounds; fish of 4 pounds or larger are preferred. In California, however, the market will accept catfish under a pound, and in several Southeastern States catfish as small as 5 ounces bring satisfactory prices. The prices farmers may expect for fresh, undressed pondgrown fish are not established as yet. Neither the farmer nor the retailer has sufficient experience with marketing pond-cultured fish. The 1956 prices received

by fishermen for river-harvested fish, however, give us relative average prices for the following species: catfish, 25 to 30 cents; buffaloes, 18 to 20 cents; carp. 6 to 10 cents per pound.

The price of fish is influenced largely by American preference for beef, pork, poultry, and mutton which can be had in unlimited supply and at reasonable cost. Processing, refrigeration, and transportation are developed so well that frozen marine fish, shrimp and oysters can be purchased in every seizable inland and coastal town any day of the year. Our large coastal cities are supplied with fresh fish in ample quantity during most seasons of the year, but surpluses sometimes exist during the seasons of most bounteous capture.

Nevertheless, we believe there may be an orderly place in American marketing for farm-grown fish. Quality of product, a stable supply and economical cost of production are things we are working to improve through fish-culture experience and research.

5. **Muddy water and floodwaters** are adverse to fish production. However they are seldom problems in the rice-fish rotation fields because levees around the fields are high enough to keep runoff water out.

6. **Invasion by wild fish** and their subsequent spawning, is a serious problem. We avoid this trouble in hatchery ponds by using water directly from wells or from runoff free from fish. In the fish-rice rotation fields, however, the water usually is pumped from lakes, streams, or other surface areas that contain fish. Swingle has shown in Alabama experiments that largemouth bass cannot eliminate all wild fish, but they do reduce the number and pounds of these fish substantially. We, therefore, rely on bass to reduce, through predation, the competition of wild fish with buffalo. As a result, 20 to 100 pounds of choice sport and food fish are produced per acre in addition to the buffaloes.

7. **Technical and financial assistance.** To determine land suitability, construction and layout for water-supply, drainage, and harvesting facilities, technical assistance from the Soil Conservation Service is available to farmers in every State. Some financial assistance (both payments and loans) is available from Federal appropriations for soil and water conservation purposes; however, most of the fish cul being attempted without such payments o

8. **Feeding** has not been done farm reservoirs.

FOOD-FISH IN SMALL PONDS

There is demand for food-fish cult produce annual crops of fish in small, s fishponds. This type of pond culture is developed on several farms in Alabama, C Tennessee and neighbouring Souteastern

The Alabama Agricultural Expe Station is conducting research on fe stocking and marketing. Red catfish is used for this. Feeding experiments her cate a cost of 12 to 15 cents per pound o The feeding formula is 35 percent so meal, 15 percent peanut meal, 15 perce meal, and 15 percent distillers dry solu Vitamin B (Swingle 1956 b). Soil Conse Service technicians are helping farmers i States where the Alabama research findin under field test.

COLD WATER CULTURE OF TRO

Large producers of trout are well lished in the northern and western State sacchusetts, Rhode Island, New York, Mi Ohio, Pennsylvania, Nebraska, California tana, Colorado, Idaho, Nevada, Washi Oregon and Utah. Trout culture is th here as elsewhere in the world, largely s ing nearly 100 percent of the food by feeding in pools or raceways of rapidly cha cool waters. The trout supply is adequa the demand.

USE OF FISH IN WEED CONTRO

Tilapia mossambica Peters were duced experimentally at Auburn. Sinc will not live at water temperatures bel degrees Fahrenheit (Kelly, 1959) they m kept in heated pools in winter except waters of southern Florida. Our inter them is chiefly in their ability to branched filamentous algae, *Pithophor* which no other control has been deve *Tilapia* produced 1,400 pounds of fish pe with fertilizer and feed in a 5-month pe Auburn (Swingle, 1957). Most of the pou however, was in fish too small in size for rican markets.

raelian carp, a common carp of Yugo-in, is being tried at Auburn also for the of filamentous algae and rooted, sub-vegetation in ponds.

CKISH AND SALT-WATER PONDS

his fourth area of demand for food-fish is in the southern coastal States, Florida, arolina, Georgia, Louisiana, and Texas. ourable soil and water conditions lie stal streams where salty water is the ter supply.

he problem of fetilizing salt or brackish as received little attention (Johnson, A system of shrimp culture has been ed for salt water (Johnson and Fielding, Attempts to grow striped mullet, *Mugil* Linn., (Johnson, 1954 b) were uneconoecause even with manuring the yield was under 300 pounds, and the price of veraged only 10 cents a pound. Therehile there is some demand for salt-water ture in America, we have only limited ues for managing such land and waters.

SUMMARY

nterest in food-fish culture in ponds is t growth in the U. S. A. Food-fish culrice fields involves a rotation of crops basis that continuous flooding of the rice 1-3 years is beneficial and economically Rice is grown for 1–2 years and the fields are then stocked with fish which vested after 3 or 2 years. Research on ual results obtainable in terms of rice h yields, the effect of the fish on soil , soil tilth, weed-seed destruction and lated subjects is proceeding.

Field trials with indigenous fishes were ed in 1954 and a number of private ries have been built.

About 500 lb. of fish per acre can be pro- and this quantity may be doubled by mentary feeding.

The American demand is for large fish, itating usually 2-3 years' growth. Small seldom in demand and bring low prices.

Although most fish culture operations are nced on individual instruction, Federal riations for soil and water conservation es can be used to provide loans and cal assistance is available for the Soil rvation Service.

Food-fish culture in small farm ponds and in brackish and salt water is receiving attention.

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A PRELIMINARY EXPERIMENT ON AGRICULTURAL INSECTICIDES AND PADDY-CUM-FISH CULTURE

by

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SUMMARY

ommonly used agricultural insecticides—
, Dipterex, Folidol, DDVP, Dieldrin and
were tested to determine the toxic effect
and other aquatic animals in rice fields,
evaluation of the toxicity of each
was made in the laboratory by the bio-
thod. Diazinon, Dipterex, Folidol and
id not show significant hazards for fish
ne methods of application adopted in
out Dieldrin and Endrin application
d the fish harvest.

INTRODUCTION

uring the last decade several kinds of
ural insecticides have been applied to
plants year after year, and the process
urther expanded in the future, because
gnized destructive effects of the chemi-
harmful insects is appreciated by farmers
as agricultural experts.

omplaints on the ill effect of the chemi-
fish and other aquatic animals, not only
addy fields but also in nearby creeks and
, have been made by sportsmen, fisher-
nd-fish culturists and farmers engaged
y-cum-fish culture. The trouble caused
use of insecticides, of course, is most
felt by the farmers raising carp in paddy

n Japan, paddy-cum-fish culture is one of
st important items in the inland fishery
y. Carp culture in rice fields has a history
one hundred years in Nagano Prefecture.
region of Japan a high percentage of the
e raised to marketable size by artificial
, but in many other regions the carp are
in rice fields to produce the fish fry which
er cultured in fish ponds. The carp in
fields mainly depend on natural food.

Details of carp culture in rice paddy in Japan are given by Kuronuma (1954).

Under the circumstances Dr. K. Kuronuma, Director of our Laboratory, with his sincere concern of the disastrous problem, desired to start scientific investigations on this line. In the present investigations the writers were required to 1) seek an understanding of the actual state of the matter, 2) determine the safe amounts of insecticides applicable, and 3) define means to reduce the ill effects caused by the use of insecticides.

The study was carried out during spring and fall, 1956, and may be divided into two main categories, the one conducted in the field and other in the laboratory. The former was undertaken in an experimental rice field at Saitama Prefecture Agricultural Experiment Station, and observations on the effect of the several kinds of insecticides on fish were made after the application of the chemicals to the paddy field planted in the ordinary way with rice and stocked with fish. An experiment designed to estimate the toxicity of the chemicals of fish and water-fleas, was carried out in the laboratory, using a thermostat which was specially designed and constructed for water pollution research in the Laboratory in 1956.

The estimation of biologically safe concentrations of insecticides for fish was made by using the theory and method reported by Doudoroff *et al.* (1951), Hart, Doudoroff and Greenbank (1945), and Orsanco (1955). The toxicity determination of insecticides for *Daphnia carinata* was suggested by Anderson (1954), and in the present experiments it was pursued by the method developed by him (Anderson 1944, 1946 and 1948).

ndo—*Pacific Fish. Coun.*, 7 (II—III): 173—181, 1957.

MATERIALS AND METHODS

1. Agricultural Insecticides Tested

In the present experiment emulsions of chemicals were used on the basis that the toxicity of the emulsified form was reported by many workers to be stronger than that *in vitro* (Mizunuma, 1956) and the spre the chemicals in an emulsion may be a to be more uniform. The market nam characters of the insecticides tested present experiment are listed (Table I).

Table I. Commercial names, chemical formula, and concentrations (in weight by volume) of insecticides

Commercial name	Chemical formula	Concentra
Diazinon	(1) *O*, *O*—diethyl—*O*—(2—isopropyl—6—methyl—4—pyrimidinyl) thiophosphate.	17.0
Dipterex	(2) *O*, *O*—dimethyl—1—hydroxy—2, 2, 2—trichloroethyl phosphate.	50.0
DDVP (Emulsion)	(3) Dimethyldichlorovinyl phosphate.	45.0
Folidol	(4) *O*, *O*—diethyl—*para*—nitrophenyl thiophosphate.	46.6
Dieldrin	(5) 1, 2, 3, 4, 10, 10—hexachloro—6, 7—*epoxy*—1, 4, 4a, 5, 6, 7, 8, 8a—octahydro—1, 4—*endo*, *exo*—5,8—dimethano naphthalene.	18.5
Endrin	(6) 1, 2, 3, 4, 10, 10—hexachloro—6, 7—*epoxy*—1, 4, 4*a*, 5, 6, 7, 8, 8*a*—octahydro—1, 4—*endo*, *endo*—5, 8—dimethano naphthalene.	19.5

2. Experiment in the Rice Field

The experiment was carried out in 14 plots of paddy field, each 99 sq.m. in area, of similar construction and agricultural treatment, which was done by experts. Paddy-cum-carp culture was conducted in 7 plots and the other 7 plots were selected as controls for the comparison of the rice harvest. The details of the method of application of the insecticides, dilution rate, volume of emulsified aqueous solution, time of operation etc., were all made after consulting and in co-operation with the agricultural scientists of the Station. Further details of this subject will be found in a pamphlet prepared by Kawada, Kato, Mu Fukunaga (1954).

An effort was made to maintain th in the rice fields as stagnant as possible the course of the study, especially af application of chemicals. However, a amount of water was supplied to the pad the irrigation canal in order to compen the loss of water due to seepage and evap The fish culture procedure used in the study follows that currently adopted farmers in Saitama Prefecture, whi surveyed by Saitama Prefecture Fisher tion in 1954.

TABLE II. Records of Carp Culture in 7 Experimental Paddy Fields Holding Water 6 to 10 cm. Deep With Insecticides Applied.

From July 11 to September 21, 1956

ber	1	2	3	4	5	6	7
	Diazinon	Dipterex	DDVP	Folidol	Dieldrin	Endrin	Control
ap. (°C)*							
	38.8	38.8	38.8	40.2	39.8	39.2	37.8
	17.8	17.6	17.8	18.0	18.0	18.0	17.6	
	28.6	28.5	29.3	29.3	29.1	29.8	28.6
O_2	No sign of "gulping-air" nor gas disease found.						
	6.2 — 9.8						
of fish	140 per Field (99 $m.^2$)						
y length (cm.) (*L*)	3.3						
y width (g) (*W*)	1.14						
Number:	27	21	27	36	0	0	41
of stock	19	15	19	26	0	0	29
ight (g)	530	400	550	1,000	0	0	760
cm.)	8.9	8.8	8.9	10.2			8.5
(g.)	19.3	18.9	20.3	28.3			18.3
10^3 (mean)	27.4	27.0	27.5	26.2			27.2

observation at noon.

With the experiment on the effect of ide on the harvest of fish, an attempt le to determine the time of toxicity con- e in the experimental paddy fields. Net 0 × 60 × 25 cm.) of synthetic fibre were n the paddy and fresh test animals were he cages every day. When a mortality than 10 or 20 per cent did not occur within 96 hours after the introduction of test animals in cages into the water in the paddy fields, it was presumed that within that time the toxicity of the chemicals had vanished.

The duration of 96 hours for the mortality detection was adopted in the present study according to Doudoroff *et al* (1951). The

selection of a mortality percentage of 10 or 20 was decided somewhat arbitrarily, because only 5 or 10 specimens were used in these tests. If the mortality is not due to accident but to the toxic action of chemicals, this toxic effect will have vanished by the time of the final for other reasons.

The results of their tests are sh Table IV, with the other data obtaine

Table III. Test animals in experiments on the toxicity of agricultural insecticides on

Name		No. used	Size	
English	Scientific name		Mean body length (cm.)	Me wei
16 July test				
Carp (a)	*Cyprinus carpio L.*	10	6.7	
Carp (b)	— do —	10	3.3	
Eel	*Anguilla japonica* (T. et S.)	10	20.7	
Gold fish	*Carassius auratus* (L.)	10	2.8	
Loach	*Misgurnus anguilli-caudatus (Cantor)*	10	8.6	
"Motsugo" Fish	*Pseudorasbora parva* (T. et S.)	5	5.3	
Cray fish	*Cambarus clarkii* (Girard)	5	8.6	
			9 (Carapace length)	
25 August test				
Garp	*Cyprinus carpio* L.	10	5.5	
Cray fish	*Cambarus clarkii* (Girard)	5	4.0	

and other data Observed.

Chemicals	Diazinon	Dipterex	DDVP	Folidol	Dieldrin	Endrin	Diazinon	Dipterex	DDVP	Folidol	Dieldrin	Endrin
	First application (16 July 1956)						Second Application (25 August 1956)					
Initial concentration,[7] ppm.	1) 0.22	1) 0.70	1) 0.55	2) 0.14	3) 0.96	3) 0.91	4) 0.44	4) 1.7	4) 1.1	5) 0.60	6) 1.3	6) 1.4
Limnological condition[8]												
Water temp, (°C)	26	25	26-29	26-27	26-32	27-36	27	27	29	22-27	22-27	24-30
pH	9.6	6.8	8.9-9.6	9.6-9.7	9.3-9.7	8.9-9.6	8.3	6.6	7.3	6.1-6.5	6.3-6.6	6.0-6.5
Depth (cm.)	6.5	6.5	6.5-8.0	6.0-6.5	5.5-6.5	5.0-10.0	6.5	6.5	6.5	6.5-10	6.5-10	6.0-11
Duration (days)												
Carp (a)	0	1	1	1	10	21	0	0	0	0	3	28
Eel	0	0	2	0	11	19	—	—	—	—	—	—
Gold fish	0	0	0	0	2	19	—	—	—	—	—	—
Loach	0	0	2	2	6	10	—	—	—	—	—	—
Cray fish	0	0	0	1	3	2	0	1	0	4	0	0
"Motsugo" fish	1	0	0	0	7	9						

1) 1/500 aq. sol., 8.1/99 m^2, depth 6.5 cm.

2) 1/2,000 aq. sol., 8.1/99 m^2, depth 6.5 cm.

3) 30 ml/99 m^2.

4) 1/500 aq. sol., 18/99 m^2, depth 6.5 cm.

5) 1/1,000 aq. sol., 18/99 m^2, depth 6.5 cm.

6) 45 ml/99 m^2.

7) Active ingredient.

8) Data at noon during the period of toxicity continuance.

3. Experiment on Toxicity Evaluation through Bio-assay

The same insecticides tested in the fields were also tested in the laboratory by the procedure of bio-assay to test the writers' understanding of the field phenomena and their judgement of the safety concentration value, as well as to provide an indication of means abatement of the ill-effects of the chemic

The technique adopted in this essentially in accordance with that recomm by Doudoroff et. (1951) and Hart, Doudo Greenbank (1945) for fish, and that by Ar (1944, 1946 and 1948) for water fleas results for fish are presented in Table IV

TABLE V. Estimated Biological Safety Concentration of 6 Agricultural Insecticides Fo Freshwater Fishes By Bio-Assay.

Fish species	Mean total length (cm.)	Mean body length (cm.)	Mean body weight (g.)	24 hr. -TLm (ppm.)	48 hr. -TLm (ppm.)	240 hr. -TLm (ppm.)	Biol. saf. concnt. (1) (2) (ppm.)	Water temp. (°C)
				——Diazinon——				
Carp		6.9	6.9	0.65	0.58		0.058	19
				——Diptrex——				
Carp	2.8		0.4	20	20	15 1.8	4.5	16
		6.0	6.5	28	25	2.5		20
Wild Gold fish	7.5		5.3	21	20	20 2.0	6.0	16
	3.1		0.5	22	16	12 1.6	3.6	16
	4.0		0.9	18	18	15.5 1.8	4.7	25
				——DDVP——				
Carp		6.1	6.4	3.8	3.4	0.34		20
Wild Gold fish	4.0		0.9	3.2	2.7	0.27		15
				——Folidol——				
Carp	3.9		1.0	4.0	3.8	2.8 0.38	0.84	16
Wild Gold fish	6.6		4.2	2.8	2.6	1.8 0.26	0.54	16
				——Dieldrin——				
Carp	3.5		0.7		0.068	0.010	0.0068	16
Wild Gold fish	7.1		4.2	0.048	0.024	.013	0.0024/ 0.0049	16
				——Endrin——				
Carp	6.3		7.6		0.022	0.014	0.0014	19

Note: Concentration in table is expressed as active ingredient.
Biological safety concentration (1) : 48 hr.-TLm × 0.1.
Biological safety concentration (2) : 240 hr.-TLm × 0.3.

testing the toxicity of insecticides for
as, *Daphnia carinata* was collected from
ield near the Laboratory and cultured
edium recommended by Anderson at
s the natural food of the carp is very
e disappearance of water-fleas alone
result in a shortage of natural food for
owever, the fecundity of *Daphnia* in the
ay be taken as a criterion for the pro-
of carp in them. The results obtained
son's method showed that the median
limit of *Daphnia* for the insecticides
the present study was far lower than
ish, and the safety concentration seemed
he order of a few parts per billion.

DISCUSSION

om Table II, it seems apparent that
s no highly significant damage due to
ication of Diazinon, Dipterex, DDVP
dol on young carp, while all the young
re killed within several hours after the
ion of Endrin and Dieldrin.

he yield in number and weight in the
Diazinon, Dipterex and DDVP were
at lower than that in the control where
ical was applied. The harvest of fish in
eriment was not satisfactory even in the
the control, but such experiences are
in the practice of fish culture in the
l and perhaps other factors were con-

the present experiment an attempt
le to protect the fish from wild birds by
ng cotton rope and steel wire over the
of paddy, but the device adopted was
ct for the purpose, and predation by
asts such as the weasel was not con-
Also the selected paddy were located
rea where paddy-cum-fish culture is not
ed intensively, and it seems natural to
that damage by predators was more
han in other areas where fish culture in
ds is carried out to a large extent. Un-
tely, it was not possible to select the
ental rice field in such a good area,
many farmers were not interested to
a hazardous experiment of this type in
ce field where they were rearing fish.
uch circumstances the yield of fish was
rably lower than expected, and natural
n is believed to be largely responsible.

From Table IV, it will be noticed that the application of Diazinon, Dipterex, DDVP and Folidol did not cause significant mortality in the carp, while Dieldrin and Endrin showed remarkably acute and prolonged toxicity. Among these first four chemicals, however, there was some difference in the apparent toxicity of chemicals in the paddy water, according to the results obtained by bio-assay (Table V), the field trials (Table II) and the lethal effects on fish in the cages (Table IV), as well as in the yield of fish (Table II). From the results as such, we can hardly justify the difference of fish yields among the 4 lots of field experiments with different insecticides solely on the basis of varied toxicity. The yield from the control fields also suggests the existence of other factors (Table II). A possible explanation of the difference in fish yield may be given on the basis of predation by natural enemies as mentioned above, although the available evidence is not conclusive.

In the comparison of the mortality detected in the rice field and the biological safety concentration estimated by bio-assay, it is necessary to estimate the actual concentration of applied chemicals in the water in the paddy field. To what extent the chemicals were precipitated in the paddy water was not determined in the present experiment. Precipitation rates vary considerably according to other investigators, and may change owing to differences in weather conditions and method of application. In the present case the value of ca. 50 % (Yamashina and Kamishima, 1956) was tentatively adopted as the probable. By using this figure, the estimated concentration of each chemical just after the application is shown in Table II. In this calculation it was assumed that the chemical fell evenly on the paddy and mixed immediately with water, since the application was conducted by using a hand sprayer and the workers operated the tool while walking through the paddy.

Because of the absorption of chemicals by the soil and other suspended matter in the paddy water, the concentration of chemicals in the paddy water may not be necessarily equivalent to the estimated figure in the table, and the concentration was probably lowered with the passage of time by the decomposition of the chemicals. The vanishing of

toxicity as pointed out before (Table II) supports this view.

The initial concentrations of Diazinon, Dipterex, DDVP and Folidol in the paddy water were slightly higher than or approximated the estimated biologically safe concentration. On the other hand, in the cases of Dieldrin and Endrin the concentration was much higher than the biologically safe concentration. There seems to be an agreement between the results obtained in the paddy fields and in the laboratory. In another experiment on the estimated safe concentration, wild gold fish showed a lower growth rate than those in the control fresh water. In this experiment, to test the validity of the safety co-efficient used for the calculation of biologically safe concentration (Table IV), the test solution was renewed once a week, but in the rice field the chemicals were applied only twice during the entire course of the study and the actual concentration might have been far lower than the figures shown in Table 3, considering the effects of absorption, decomposition, seepage and other factors.

In this connection we believe that tracing the history of the chemicals in the paddy water especially the rate at which their toxicity diminishes will throw a light on the problem of abating the toxic effects on fish cultured in the paddy fields.

It is certain that the water flea, *Daphnia carinata*, cannot survive in paddy water treated with the agricultural chemicals used, and it might be considered that the loss of fish food organisms would result in a marked decrease in the growth of the fish. However, so complex is the food of the fish in the paddy water that the application of chemicals sufficient to kill *Daphnia* may not necessarily cause a decrease in the fish harvest. Although the decrease of the crustacean was observed after the application of the chemicals, most of the zoo-plankton did not show a noticeable decrease, and a decrease of the growth or of the harvest of fish in the paddy fields where chemicals were applied was not shown.

In this experiment in rice fields, the chemicals for preventing blast or "imochi-byo", a kind of disease of rice plant caused by a fungus, were not applied, in order to concentrate solely on the effect of insecticides on fish. Unfortunately the blast disease spread over the experimental paddy fields, hence the ha rice in the experimental paddy field ca used for considering the effect of pad fish culture practice on rice harvest.

CONCLUSIONS

1) A preliminary experiment on t of some agricultural insecticides, emulsi of Diazinon, Dipterex, DDVP, Folidol, and Endrin (Table I), was made in field of the Saitama Prefecture Agri Experiment Station and water pollut ratory of the Fresh-water Fisheries R Laboratory, Fishery Agency in 1956.

2) The results concerning fish toxicity continuance in paddy water an gical safty concentration estimated by b are shown in Table II, III and IV respe

3) The chemicals, except Dield Endrin, applied by the standard method in Japanese rice fields did not show effects on the carp fry in the paddy field

It was concluded that Dieldrin and should not be applied in paddy fields wh culture is practised. If the fish culture conducted in the paddy field and padd could be maintained stagnant for more t week, Dieldrin may be used without de damage to the fish in the neighbourhood paddy.

The reason that the application o non, DDVP and Folidol did not sh significant hazard to carp fry in the padd in spite of initial concentration being than the biological safety concentratio estimated by bio-assay, probably depe the rapid decrease of toxicity of the ch in the paddy water.

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PISCICULTURE IN RECLAIMED SWAMPS AND ITS ROLE IN RURAL ECONOMY IN ORISSA

by

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ABSTRACT

A considerable number of small and large swamps ranging between 4 and 1,000 in Orissa are totally unproductive and contribute to insanitation and malaria. Owing ıvy reclamation costs and uncertain income, swamps had not been reclaimed either ıgriculture or for pisciculture. Experiments were conducted to reclaim a large number ıamps and to work out their economics. A new technique to reclaim deeply silted ıps at low cost had been evolved by subsoil pumping and a silt berm which raises ı by pressure from below. The bunds can be completed without the use of protective Small swamps yield between 400 and 800 lb. per acre while large swamps where ıing has to be done at random yield only 100 lb, but they are economical on account ıv establishment costs. Details of expenditure on and income from a few swamps are . Biological conditions and the effects of manuring of swamps have also been studied ıularly with reference to growth of plankton and yields of fish and a few typical are described. It is concluded that the increased production from swamps reclaimed ıding to the new technique would add considerably to the rural income and provide ıyment to a number of persons.

INTRODUCTION

he State of Orissa (India) has an area of quare miles with 60,000 villages. The ɔulation, 95% of the total, depend mainly vation of paddy, home industries and ure, the production from which deter- ıe economic condition of the villages. on land is heavy, averaging 244 persons are mile. Paddy being the main crop ıfall varying between 50 to 65 inches in ılmost every village has a swamp ranging 4 and 1,000 acres. These areas are y unproductive of either paddy or fish tribute considerably to the incidence of Rendering these swamps productive therefore, play a significant part in the onomy.

swamps by virtue of their origin and ɔf neglect require different treatment but ly, the reclamation costs are heavy and be kept down within the limits com- ate with possible returns in terms of ion. "Most ponds are too big, scientists ıd the expenses and labour involved in per management of a large pond are too great for the average individual". The same holds good for swamps also, but in the case of large swamps, dykes dividing the swamps into workable units have to be made with silt alone to avoid the shifting of soil over long distances, suitable earth not being available nearby. Planning the conversion of swamps into fish farms with various types of tanks requires considerable experience and care. Such planning has to be based on the amount of silt, weeds, the nature of water and the type of operation required e.g. deweeding, desilting, construction of cross embankments etc. The technique of construction of cross dykes in deeply silted swamps at a low cost is new and requires a good deal of experience for successful application. The problems have been the lack of (i) initial (ii) enterprise (iii) technical advice and (iv) data on the economics of fish farms made out of reclaimed swamps.

THE EXPERIMENT

Swamps were taken up at random all over the State of Orissa for reclamation on an experimental basis and the technique of reclamation including planning was evolved

ıdo—*Pacific Fish. Coun.*, (II—III): 183—185, 1957.

as work progressed, there being a number of errors in the location of different types of tanks, nature of sluices and other constructional details in the beginning. In fact, the most economical method of constructing silt dykes was evolved only in 1956. Table I shows the yields from selected swamps of different soil conditions converted into fish farms. Usually it to seasons (January—June) for the completi project and fish was marketed thereafte ally, due to needs for quick returns, al the fish had not reached the best mar size. This no doubt contributed to so lower yields.

Table I. Showing the cost of Reclamation per acre in different swamps.

Sl. No. Name of Swamps	Gross Income up to March	Initial condition	Capital Investment in rupees	Water area in acres	Cost per acre (Rs.)
1. Satabandha Project, Sonepur	Rs. 18,385	Deeply silted..	31,237	17.57	1,785
2. Rajamunda Project, Boudh Raj	Rs. 6,752	Small irrigation project.	29.514	14.79	2,001
3. Kusumbi Project, Jaypur	Rs. 8,639	Deeply silted	85,612	22.54	3,805
4. Nuapara Project, Kujang	Rs. 3,100	-do-	19,927	3.40	5,695
5. Baidyanath Sagar & Narayan Sagar Project, Angul	Rs. 5,295	Laterite bottom.	67,557	18.80	3,603
6. Chatra Sagar & Khajurkota Project, Sambalpur	Rs. 18,187	Low land without silt	38,640	14.00	2,760
7. Kausalyaganga Project, Puri	Rs. 57,224	Deeply silted.	378,080	131.07	2,885
8. Mahabhoi Project, Kendrapara	Rs. 6,394	-do-	7,467	3.75	1,991
9. Jamalpur Project	Rs. 2,755	-do-	4,289	2.05	2,092

General observations on swamps may be summarised as below.

1. Swamps are generally acid and contain very little fish, contrary to public expectations.
2. Deeply silted swamps although more expensive to reclaim are productive in both fish and vegetables, the acid areas developing productivity after one or two years.
3. Small irrigation projects being a water source for crops suffer severely for 2 due to drought.
4. Irrigation projects with laterite bot poor in production.
5. Small village swamps are the most pro especially on account of food supplie fish in various forms resulting from of the tank by the villagers.
6. Incidence of malaria is noticeably les swamps beside villages have been cl

ne scheme was worked out on the basis ould cost Rs. 2,500 to reclaim an area of and the yield would be Rs. 200 per acre hat the capital cost would be recouped period of 15 years without interest on The first two years would be regarded ductive. The success of the scheme depended on the low initial capital economical reclamation work and conti- production for at least 12 to 15 years, major capital expenditure being unneces- is obvious that to assess results the has to be worked for a long time but dications of results can be seen from The Satbandh Project with an initial Rs. 31,000 has given a gross income of 00 in four years (excluding the first two The expenditure is within 15% of the and as such the scheme has been econo- Similarly, Series Nos. 3, 4, 5, 6, 7 and 8 economical and all of them are deeply vamps. In case of Rajamunda (Serial which is a minor irrigation project, the as low on account of the fact that in one year affected fish production for two years and the tank had to be cut to ater for irrigation in the year of drought. of Serial No. 5 the yield was the lowest s a laterite bottom and production was

Generally, however, with the technique now improved, deeply silted swamps of almost any size can be reclaimed with capital on a long term basis, free of interest (this is necessary because some of the swamps have been neglected for hundreds of years e.g. Serial No. 6 had not been reclaimed for 600 years and naturally the silt deposits were very heavy). There is therefore considerable scope for swamps to play a useful role in rural economy and it is necessary to organise enterprise and to provide capital along with improved technical knowledge.

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OBSERVATIONS ON THE CULTURE OF BRACKISHWATER FISHES IN PADDY FIELDS IN WEST BENGAL *(INDIA)*

by

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SUMMARY

he culture of brackishwater fish in rice widely spread in West Bengal. The constructed along embankments and ided with well built drainage canals. ter enters the canals carrying several of estuarine fishes. After the early bunds are cut to allow the merging of l water and that in the paddy field and hen obtain access to an increased water uring October and November, the water the fields decreases and the fish the canal whereupon fishing operations ce. About the time of harvesting the e canals are bunded off into small d seine nets remove the last of the fish During the rainy season, the water in dy fields has a salinity less than 0.5‰ inant algae and phytoplankton genera d as also are the important species of prawns cultivated. Notes on feeding f these species are included and a table the growth of several species during er-November is given.

roduction is estimated at 100—200 kg. are. It is suggested that improvements ing practice, including the transplanta- fry from other sources could increase ion appreciably.

INTRODUCTION

ish culture in paddy fields is widely d in some of the Indo-Pacific countries Indonesia, Japan and Malaya. In India, ctice of retaining and harvesting prawns enter the paddy fields at the time of g, is followed in certain areas of Kerala (Panikkar, 1937, Menon, 1954 and th, 1955). Alikunhi (1955) has stated llets and *Etroplus* spp. form an apprec- art of the catch from such fields. Small xperiments on the culture of fish in paddy fields have been undertaken in recent years in the States of Madras, Mysore, Orissa and West Bengal with mostly inconclusive results. (Chacko and Ganapati, 1952; Iyengar, 1953 and Hora, 1951). During an investigation on the productivity of brackish water *bheris* in West Bengal, which is now under progress in this Station, it was observed that there is a wide-spread practice of culturing brackish water fishes in paddy fields in certain areas of the State. As this indigenous practice differed in many respects from the usual method of culturing freshwater fishes in paddy fields, it was considered worth while to study it in some detail. This report is largely based on observations made in selected paddy fields at Hasnabad and Basirhat in the District of 24 Parganas during the current year.

The authors are thankful to the owners of these paddy fields for the facilities afforded for observations and to Shri N. Dutta of this Station, for his help in the identification of plankton and benthic biota referred to in this report. Thanks are also due to Dr. B.S. Bhimachar for his keen interest in this investigation.

METHOD OF FISH CULTURE

The paddy fields in Hasnabad, Sandeshkhali, Basirhat and Barasatthanas (24 Parganas District, West Bengal), where paddy-cum-fish culture is practised, are situated along the tidal rivers of Ichamati and Raimangal and their tributaries. The fields have strong embankments all round, especially on the side facing the river, to protect them from tidal flooding. Each field has a canal system of varying size and design, mainly meant for the drainage of excess rain water. In some, the canal runs all round the field, whereas in others it may be only on one or two sides. In addition, there may often be a central canal with a net-work of branches. On

an average about 8% of the area of such fields is occupied by canals varying from 0.6 to 1.5 m. in depth. The mouths of the main canals leading to the river from many of the fields are guarded by sluice gates with concrete frame work, to effect proper regulation of drainage (Plate, Fig. 1). Most of these fields are utilized for culture of fish, both before and during the period of paddy cultivation.

Very few modifications or additions are required for utilizing the paddy fields for fish culture. The embankments are generally maintained sufficiently high and strong to protect the field from tidal flooding.

The canals are generally kept in good repair (Plate, Fig. 2). The mouth of the canal leading to the river is provided with a bamboo fencing of the type commonly erected in brackishwater *bheris* (Hora and Nair *op. cit.*; and Pillay, 1954) to prevent the escape of fish from the canals at the time of letting out water and to help in the capture of fish from the canals by means of traps, when required (Plate, Fig. 3).

Harvesting of paddy is generally commenced in this area in the month of November and is over by about January, when the field as well as the canals are completely dry. From February or March onwards tidal water is taken into the canals at high tides. During spring tides when the tidal flow is strong, the young of estuarine fishes that occur in the area during that time gain access to the canals. Till the onset of the monsoons the water level in the canals is maintained at about 30 cm. below the level of the paddy field, the depth of water varying between a few cm. in shallow areas to about 1 m. in the deepest portions. The young fish that enter the canals have conditions favourable for their growth on account of the shallowness of the canals and the appreciable growth of benthic biota in them.

The feeding of tidal water into the canals is stopped by about the month of June when the south west monsoon sets in. The fields are then prepared for the planting of paddy seedlings, which is done about July. In most fields, manures such as cowdung, bone meal, ammonium sulphate, superphosphates, etc. are ap
The strains of paddy cultivated in this ar
salt resistant and the seedlings are plan
distances of 20 to 23 cm. By August the
level in the canals increases to between 0
1.5 m, due mainly to the accumulati
rainwater, when the paddy plots also get
ated. The bunds along the canals are th
so as to merge the water in the canals a
paddy plots, and this enables the fishes t
access to the latter (Plate, Fig. 4). The
of water in the paddy plots varies consid
from a few centimetres to as much as over
If the water level in the paddy field inc
abnormally, the excess water is drained o
the river through the sluice gate, during
of low tide, and the bamboo fencing pro
the sluice prevents the escape of fishes fr
field. If required, river water is taken in
canals during the latter half of the m
season when the water of the river is prac
fresh (salinity being less than 0.5%). By
the month of October or November wh
rainy season is over, the water level in the
plots decreases appreciably and in most
the fields dry up completely. The fish
move back into the canal, when the
operations are started. All the fish fr
canals are not caught at the same time. A
able quantities of fish are obtained every
letting in water at high tides against wh
fish would swim and get caught in the tr
in the gaps between the bamboo fenci
quantity of fish is also caught by allowin
to enter narrow ditches along with tida
at high tides and then draining the d
Finally, just before or after the harves
paddy, the canals are bunded off into
portions (Plate, Fig. 5) and thoroughly
with seine nets to remove all the fish
Fig. 6).

ECOLOGICAL FEATURES OF THE PADDY FIELDS

One of the major features of the
fields in this area is the fluctuating sali
the water in the adjoining canals. Th
salinity of the water in the canals dur
period of fish culture is given in Table I.

Table 1. Mean salinity of water in the in the paddy-cum-fish culture plots.

nth	Salinity in ‰
bruary	15.8
rch	no analysis
ril	21.3
y	31.5
ıe	9.4
y	2.2
gust	< 0.5
ptember	< 0.5
tober	< 0.5
vember	< 0.5

It would be seen from the above that the in the paddy fields is almost fresh from t onwards.

During the dry months, when fry remain canals, the water in them is shallow. ciable rise in the water level takes place the monsoon season, when the fish move ıe paddy plots. The water level in the plots varies from a few cm. to about 30 to The low water level and relatively high rature appear to be conducive to the n of benthic biota which form the food of ultivated in the paddy fields. The zers applied in the paddy fields serve to se the productivity of benthic and plank-biota to a considerable extent. Examination physical and chemical properties of soil es from representative paddy in the area d the following mean values:

s...	2.21 %
gen (Total)	118 mg. N/100 g. soil
rent density	0.90
ic gravity...	1.80
holding capacity ...	75.80
pace	58.80
ıe expansion	6.20

Among the benthic algae that grow in the and in the paddy plots, the predominant tuents are species of Oscillatoria and ns. *Anabaena*, *Lyngbia*, *Cladophora* and *Vaucheria* also occur in the fields. Among the diatoms the dominant genera are *Nitzchia Pleurosigma* and *Gyrosigma*. Appreciable numbers of *Surirella*, *Navicula*, *Amphipleura* and *Cymbella* are also found in the fields, besides fungi, and desmids. The plankton in these paddy fields is dominated by phytoplanktonic elements among which *Euglena*, *Oscillatoria Lyngbia*, *Anabaena*, *Spirogyra* and various genera of diatoms and desmids are conspicuous. The more important diatoms belong to the genera, *Nitzchia*, *Gyrosigma*, *Navicula*, *Surirella* and *Cymbella*. The major zooplanktonic organisms found in the plankton are, flagellates, copepods, rotifers and nauplius larvae.

THE CULTIVATED FISHES, THEIR FOOD AND GROWTH

The major species of fishes, the young of which are taken into the paddy fields for culture are the following:

(1) **Grey mullets** : *Mugil parsia* Hamilton
Mugil tade Forskoal
Mugil corsula Hamilton

(2) **Bhekti** : *Lates calcarifer* (Block)

(3) **Tengra** : *Mystus gulio* (Hamilton)

(4) **Prawns** : *Palaemon carcinus* Fabricius
Penaeus semisultatus De Haan
Palaemon rudis Heller
Metapenaeus monoceros (Fabricius)
Metapenaeus brevicornis (Milne-Edwards)

Besides these, extraneous species like *Glossogobius giuris* (Hamilton), *Scatophagus argus* (Block), *Pseudapocryptes lanceolatus* (Block and Schneider), *Palaemon birmanicus* Schenkel, *P. lamarrei* Milne-Edwards, *Leander styliferus* Milne-Edwards and *L. fluminicola* Kemp, also find their way into the paddy fields.

The examination of gut contents shows that all the three species of grey mullets cultured in the paddy fields feed on detritus and benthic algae including diatoms and desmids. The main food items of Bhetki in the paddy fields are prawns and small fishes. *Mystus gulio* exhibits omnivorous feeding habits, the main constituents of its food being detritus, zooplanktonic organisms, small prawns, green and blue green

algae, etc. The main food of the prawns also in the paddy fields is detritus. Large individuals of *Palaemon carcinus* have been found to feed also on other smaller prawns. Females of *Palaemon rudis* were observed to be in berried condition in the fields in October and November.

As already mentioned, the river water is taken into the canals in the paddy fields from February-March to June.

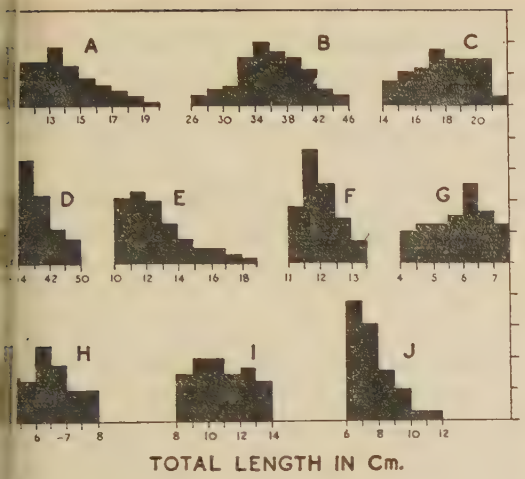
The young of mullets that enter the fields during the period generally measure between 2.5 to 5.0 cm., Bhekti about 10 cm. an prawns between 1.5 and 3 cm. It was p to obtain samples of fish from the pa for studying the growth, etc., only from ber onwards, when fishing operations conducted. Even during this period, ad samples of all the species were not availa November when total fishing was done. growth data collected from Septemb November are summarised in Table II.

Table II. The growth of fishes in the paddy fields.

Species	September			October			November	
	Length in cm.			Length in cm.			Length in cm.	
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
Mugil parsia	6.2	8.2	7.0	11.0	12.0	11.1	9.0	19.0
Mugil tade	14.9	16.2	15.6	17.3	19.7	18.0	27.1	43.2
Mugil corsula	—	—	—	—	—	—	16.5	22.0
Lates calcarifer	11.7	15.3	12.9	16.9	22.1	21.5	27.9	48.7
Mystus gulio	6.3	6.9	6.5	9.6	11.7	10.6	10.0	18.5
Penaeus semisulcatus	—	—	—	9.5	10.9	10.2	11.0	12.6
Metapenaeus monoceros	—	—	—	—	—	—	4.4	7.6
Metapenaeus brevicornis	—	—	—	—	—	—	4.7	7.1
Palaemon carcinus	—	—	—	—	—	—	8.7	13.1
Palaemon rudis	—	—	—	8.2	9.5	8.9	6.0	11.0

The rate of growth of the mullets is remarkably high compared to that observed in natural waters. (Pillay, 1954 and Sarojini, 1956) and roughly equals their recorded growth in *bheris* (Pillay, 1954). But the growth rate of Bhekti is strikingly higher. The possibility of fish remaining in the fields after the annual fishing was investigated. Since both the paddy and canals are fully dried at the time of ha ing there is very little likelihood of an remaining in the field for a second s Further, the length frequencies of the show clearly that they all belong to on group (fig 7).

. Sluice gate at the mouth of the canal in a paddy field.
. The canal system in a paddy field into which young of brackish-water fishes are taken during the pre-monsoon period.
. Bamboo fencing protecting the canal leading to the paddy field.
. Merging of water in the canals and paddy plots, during the monsoon season, enabling the fishes to graze among the paddy plants.
. Bunding off the canals for fishing.
. Fishing with hand seines in the canals.



ength frequency distribution of fishes caught rom the paddy fields in November, 1956.

gil Parsia	F. *Penaeus semisulcatus*
tade	G. *Metapenaeus monoceros*
corsula	H. *M. brevicornis*
es calcarifer	I. *Palaemon carcinus*
stus gulio	J. *P. rudis*

Smaller prawns like *Palaemon birmanicus* o a mean length of 5.5 cm., *Palaemon i* 3.8 cm., *Leander styliferus* 4.6 cm. and *flumincola* 3.9 cm.

Among the extraneous fishes found in ddy fields, *Glossogobius giuris* attains a of 15 to 17.5 cm., *Scatophagus argus*, 6 to , and *Pseudapocryptes lanceolatus*, 10-12 November.

PRODUCTION

Mainly on account of the fact that fishing paddy fields is extended over a period of 3 months, it has not been possible to accurate data regarding the production from the paddy fields. From enquiries uring the season, it has been found that s wide variation in the yield.

Even though the stocking operations are crude, the analysis of sample catches he paddy fields shows that only 2% of ight of fishes in the catches consist of nomic species. About 32% (by weight) catches of cultivated species, consist of *Mugil parsia*, 14% *M. tade*, 16% *M. corsula* and 34% *Lates calcarifer*. Though the number of *Mystus gulio* in the catches is high, it constitutes only about 4% of the catches by weight Among the prawns, the more important species are *Palaemon carcinus*, *Palaemon rudis*, *Penaeus semisulcatus*, *Metapenaeus monoceros* and *Metapenaeus brevicornis*.

The observations made so far would appear to indicate that by improving the stocking practice, the yield of fishes that fetch a higher price in the markets can be considerably improved. Instead of depending on the tidal currents for stocking, fry of desired species can be collected from the river or other areas and planted in the fields. Though it is extremely difficult to assess the percentage survival of the cultivated fishes in the paddy fields on account of the present system of stocking the abundance of the fishes does indicate an appreciable survival rate. The fear among some farmers that the practice of taking in the tidal water into the paddy fields for fish culture is harmful to the paddy plants does not seem to be substantiated, as the water in the river and in the canals is almost fresh at the time of paddy planting, and especially when the waters from the paddy field and the canals merge. Further, the varieties of paddy cultivated in the area are salt resistant.

During this investigation it has not been possible to collect any evidence of this practice having affected the production of paddy. The culture of brackishwater fishes in paddy fields would, therefore, appear to have great possibilities in deltaic areas of India where fry of brackishwater fishwater are easily available.

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FISH CULTURE IN RICE FIELDS—A PRELIMINARY REVIEW AND ANNOTATED BIBLIOGRAPHY

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esent list totals eighty-one publications, of which all those that were available have been ed. Items which were not available for perusal at the time of preparing this paper are y title only and are marked with an asterisk. The annotations merely represent the otions and views of the respective authors. Numbers in brackets in the review indicate number of references.

The wet land milieu of rice being con- o fish life, the farmer, from the earliest f rice cultivation, must have noticed fish ng about the submerged rice stalks and ave caught and eaten them whenever peared handy. The practice of regular of fish in rice fields is stated (1) to be ord in Indonesia for the past hundred Early in the present century, Nicholson ocated fish culture in the extensive rice Madras. Instances of fish crops obtained ce fields have since been reported from ina (51), Arkansas (11), British Guiana ritish West Indies (16), Burma (64), lia (64), Ceylon (20), Egypt (58), Haiti ong Kong (37), India (3, 16, 26, 35, 54, 59, 69), Indonesia (1, 13, 20, 30, 31, 63, 64, ly (18, 55, 61, 62, 64, 77), Japan (29, 42, Madagascar (45), Malaya (28, 47, 64, 69, geria (69), North Borneo (64), Pakistan 65), Philippines (20, 64, 79), Spain (23), (17, 19, 20), Tanganyika (69), Sonla in Vietnam (56), and Thailand (19, 50, 64).

The FAO Rice Committee, at its Baguio g in 1948, recognized the importance of lture in rice fields, and the next year the received attention at the United Nations fic Conference on the Conservation and tion of Resources (29, 35). Subsequently, been the subject of discussion at several s of the Indo-Pacific Fisheries Council , the General Fisheries Council for the rranean (GFCM), the FAO Rice Meeting e International Rice Commission (IRC), 26, 30, 54, 55, 64, 67, 68, 75, 81). The sing importance of the problem is evident ts forming the subject of the Symposium 7th Session of the IPFC and from the ation of a joint programme by the IPFC and the IRC for promoting investigations to evaluate the utility of fish culture in rice fields and to the extent that this should prove desirable, to develop the techniques thereof with reference to the varying conditions of rice fields and to the suitability of different fish. The national programmes of fisheries and agricultural research in several countries of Asia and the Far East appear to have included this subject among their studies. In the United States a Bill was introduced in the Congress in March 1957 with the object of promoting research and experimentation on the commercial production of fish in flooded rice fields in Arkansas (11). At this juncture it is felt that this preliminary review and bibliography which has been prepared in response to the Indo-Pacific Fisheries Council's resolution in Paragraph 136 of the Summary Report of the 6th Session of the Council, will prove useful to the administrators, executives and research workers concerned.

Exploitation of rice-field fisheries falls generally under the following categories:

(a) Harvesting the wild fish crop which may gain entry into the field through communicating water courses (e.g., 35);

(b) Augmenting the wild crop in the field by deliberate stocking either directly in the field or indirectly in connected ponds, wells, etc. (e.g., 75);

(c) Trapping prawns and fish admitted into the field with tidal waters through regulators (e.g., 26, 54, 59);

(d) Activity mentioned in (c) with an interval of growth between trapping and capture (e.g., 54).

In relation to the rice crop, fish culture may be:

(i) as a single annual crop after the single annual crop of rice (1, 35, 36);

(ii) as an intermediate crop between the rice harvest and the next transplantation in fields with rice crops of more than annual frequency, as for instance, three rice crops in two years (1, 31, 35, 36);

(iii) concurrent with the growing rice crop (1, 31, 35, 36).

According to the duration of adequate water level in the field and the size of the fish-stocking material available, the fields may be utilized for raising: i. fry (a) to fingerling or (b) to table size, or ii. fingerlings to table size (29, 43). The field system, especially the connected ponds and wells may also be used as breeding grounds for brood stocks (47, 75).

The recorded annual fish production rates from rice fields vary very greatly; e.g., 3 kg. per ha. (35) and 303 kg. per ha. (17).

The important fishes observed to tute the fish crop in rice fields in di countries are shown in Table I.

Views on the effects of fish culture rice crops are often conflicting, some ob claiming beneficial effects, others to the co (3, 17, 25, 36, 42, 55, 68, 75).

The significance of fish culture i fields in the control of malarial mosquito engaged the attention of a few workers (51).

While some observations are on on the compatibility and combinations species and their stocking densities for in rice fields (e.g., 29, 35, 47, 75), fertiliza the field and feeding of the fish as they rice and fish (e.g., 17, 25, 68), predato their control (e.g., 37, 47, 56), and the eco of fish culture in different types of rice (e.g., 17, 18, 36, 66), continue to be amo problems awaiting proper elucidation by research.

Table I. Fishes constituting fish crop in rice fields in different countries.

Fish	Country	Reference
Anabantidae:	Malaya	28
Anabas testudineus	,,	75
Trichogaster pectoralis	Pakistan	65
	Malaya	70, 71, 74, 7
T. trichopherus	,,	75
Atherina bonariensis (Kingfish-Perjerrey)	Argentina	51
Buffalo (*Lepomis* sp.)	Arkansas	11
Carassius auratus	Japan	29, 42
	Madagascar	45
	Sonla in North Vietnam	56
Carp:	Arkansas	11
	Hong Kong	37
	Indonesia	13, 78
	Italy	18, 55
	Japan	29, 42
	North Indochina	14
	Pakistan	65
	Spain	23
	Sonla in North Vietnam	56
	Unspecified	7

	Country	Reference
s carpio	Indonesia	1
	Madagascar	45
atla	India	35
i mrigala	,,	35
rohita	,,	35
laris	Sonla in North Vietnam	56
lows	India	16
ilus hasselti	Indonesia	1,65
s javanicus	Indonesia	1
sh	Malaya	28, 73
batrachus	,,	77
,,	Unspecified	66
catfish	Arkansas	11
urus lacustris)	,,	54
nos	India	54
	Unspecified	7
ossambica	Indonesia	1, 19, 20, 30, 31, 78
	Ceylon	20
	Malaya	47
	Philippines	20, 79
	Taiwan	17, 19, 20
	Thailand	19, 50
elanopleura	Pakistan	65
lotica	Egypt	58
lli	,,	58
lapia polleni	Madagascar	45
us suratensis	India	54
rl spot)		
	Unspecified	7, 16
temmincki	Indonesia	1, 63
	Malaya	47
s anguillicaudatus	Japan	29, 42
	India	54
	India	3, 16
icephalus spp.)	Unspecified	7
	Malaya	28, 47
us	India	3
	Malaya	75, 81
latus	Sonla in North Vietnam	56
nus goramy	Malaya	47
us asotus	Sonla in North Vietnam	56
sus altivelis	Japan	42
u fish)		
	India	16, 26 59, 60
penaeus dobsoni	,,	54
monoceros	,,	54
us indicus	,,	54
eels	India	16

BIBLIOGRAPHY OF FISH CULTURE IN RICE FIELDS

1. Ahjar, (1955). Rice Fields Fish Culture in Indonesia. *FAO International Inland Fisheries Training Centre, Bogor, Indonesia.* Mimeographed lecture 5.64, FAO, Rome.

   Fish culture is practised in 65,000 ha. of Indonesian rice fields, of which more than 50 per cent. is in West Java. The practice is on record for the past 100 years. Of the 12½ million ha. of rice fields in Indonesia, about 4¼ million ha. might be utilized for fish culture. *Cyprinus carpio* is most commonly cultured. *Tilapia mossambica, Osteochilus hasselti, Helostoma temmincki* and *Puntius javanicus* are also used.

   Three types of culture: (i) In fields with a single annual rice crop, fish is a second annual crop. (ii) Where rice crop is more frequent, e.g., three crops in two years, fish is raised between the rice harvests and the next transplantation. (iii) fish along with rice. In all the three, the fry may be raised to fingerlings or fingerlings to table size, which in Indonesia is 15 cm. or 100 g. The culture operations in the three different types are described. Manuring is effected by constructing stables in a corner of the field or adding rice bran, compost or leaves into the field.

2. Ahmad, N. (1956). Paddy-cum-Fish culture. *Agriculture Pakistan*, **VII** (1): 1—9.

3. Alikunhi, K.H. (1955). Rice-Field Fish Culture outside Indonesia. *FAO International Inland Fisheries Training Centre, Bogor, Indonesia.* Mimeographed lecture 5.63 FAO, Rome.

   The three general methods of fish culture in rice fields and the cultural practices current in Japan, Malaya, Hong Kong, Taiwan, Philippines, Ceylon and India are described. Some data on annual average fish yield from rice fields with and without artificial feeding are given. Species cultured in rice fields are listed. The advantages and disadvantages of fish culture in rice fields and the problems connected with such culture are discussed.

4. Ananiades, C. (1953). Agrarian Fish C and Breeding of Carp in Rice *Hellenian Hydrobiological Institute, Publ.*, No. **15**, 34 pp., illustr. (In Gr

5. Anon. (1943). Pratique de la pisci en rizières au Tonkin. *Gouvernment G de l'Indochine, Hanoi.*

6. Anon. (1951). Pedoman Perikana Tawar. *Kantor Perikanan Darat, Dj Indonesia.*

7. Anon. (1953). Fish and rice in Sou East Asia. *Rice Meeting in the Fa FAO Secretariat Paper*, No. 9, (mimeographed).

   Carps, murrels, gobies and cichlid contribute to a wild fishery in rice Deliberate planting of select spe resorted to with profit in some areas shallow fields when associated wi channels and connected ponds excellent pasture grounds for t which can retreat when necessary deeper water. Fish culture in ric is met with in Indonesia, China, Viet Nam, Malaya, India, Madagas Italy, and experiments are being in in Burma.

8. Anon. (1954). Pisciculture. *Mem. Dep Madras*, No. **36**: 1283—1286.

   Attempts at fish culture in rice fie Agricultural Research Station, Adu Bapatla Agricultural College and varam farm in South India are des The operations lasted for about years (1933—36) at Aduthurai and seasons (1948—49) at Bapatla. W assured water supply during th season by regulated irrigation fr Cauvery river, fish culture was p especially from the time the you plants could protect fish from undu up to the end of the rice season, w irrigation was cut off. The contin the fish crop was facilitated by trenches leading to a fish pond. carp and snake-head entered the

ough the drainage vents which were arded with one-way screens. The mixed ni-wild crop thrived until the experi- nt was discontinued in 1936 for reasons t mentioned. A suggestion for selected p culture is offered.

account of inundation during the rainy nths and water shortage in the supply annels in the dry season, rice-cum-fish lture was not successful in Bapatla and eravaram.

n. (1955). Fish Culture in Rice Fields. oc. *Indo-Pacific Fish Coun.*, **6**, *Agenda Item* 11, 2 pp. (mimeo).

ting on the recommendation made by e International Rice Commission at its Session, the item "Promotion of search work which would lead to a tter understanding of and improvements the practice of growing fish in flooded e fields" was included in the agenda the 6th Session of the Indo-Pacific sheries Council. A questionnaire to rve as a basis for the briefing of the legations was attached as IPFC C55/7-B.

ne document cites a section of the eport of the 4th Session of the IRC to ress that food preferences and socio- onomic conditions in the different untries will have to be taken into nsideration in planning and executing h culture in rice fields.

n. (1955a). International Rice Commis- on-Fish Culture in Rice Fields. *FAO sh Bull.* **VIII**, (1): 39—41.

he Proceedings of the 4th Session of the ternational Rice Commission relating to h culture in rice fields are briefly ported on. The working paper presented the FAO Fisheries Division and the perience papers furnished by representa- ves of Malaya, Taiwan, India, Indonesia, pan and Italy are discussed.

he Commission recommended that lember Governments be advised of the sirability of formulating a programme investigation of the problems of this ork, and it is suggested that the Indo- acific Fisheries Council should give tention to the technical aspects of these roblems.

11. Anon. (1956). Rice and Fish Crops in Arkansas. *Progr. Fish-Cult.*, July.

About 50,000 of the approximately 1 million acres of rice lands in the Arkansas State are stated to be used for commercial fish production. After the rice harvest, the fields are flooded by pumping and stocked with carp, buffalo and channel catfish. The fish is caught at the end of two years. On a hit-or-miss basis, the farmers who succeed in propagating the fish, especially buffalo and catfish, make good profits. Game species reared by the rice growers are kept for sport fishing.

12. Anon. (1957). Commercial Production of Fish on Rice Lands. Proceedimgs of 85th U.S. Congress-Session I. *U.S. Fish and Wildlife Service, Commercial Fisheries Branch Report*, 1 p, (Dittoscript).

A Bill introduced in the Senate on March 12, 1957, intends to authorize the Secretary of Agriculture to establish a programme of research and experimentation to develop commercial production of fish on flooded rice fields in rotation with rice and to contract with the University of Arkansas and to seek the assistance of the U.S. Fish and Wildlife Service in implementing the provisions of the Act.

13. Anon. (1948). Reports on Rice Paddy Culture Experiments 1946, 1947, 1948. *Fisheries Agency*, Ministry of Agriculture and Forestry, *Government of Japan*, Tokyo.

14. Anon. (1949). Report on Fish Culture Questionnaire-FAO. *Fisheries Agency, Ministry of Agriculture and Forestry, Government of Japan*, Tokyo, 40 pp., bibliography (in English).

15. Anon. (1956). Circular Letter to Administrative Correspondents. *Indo-Pacific Fish. Coun.*, ExCo 55/4, 5 pp. (Mimeographed).

Suggestions for repeated experiments with different combinations of fish species in various types of rice fields under different conditions of fertilization and supplementary feeding with adequate control observations are offered with a

view to assessing the utility of deliberate fish culture in rice fields.

16. Anon. (1956a). Questionnaire on Fish Culture in Rice Fields - Revised. *Ibid*, ExCo 56/17, 2 pp. (Mimeographed).

The questionnaire dwells on a dozen points of information covering availability of suitable area, present or future programmes, distinction between regular culture and exploitation of wild crops occurring in the fields, nature of stocking material available and its source, density of stocking, sequence of cultivation, constructional requirements and their effects on rice area, relation to rice crop, local demand and potential interest and control of pests tampering with embankments.

17. Benas, J. (1932). Notes on the Culture of Carp in the Ponds and Rice Fields of Bandung, Java. *Compte-Rendus des Séances de l'Académie d'Agriculture de France*, **18** (7): 930—920 (in French).

Carp culture in rice fields including fertilization of the waters, production per hectare and other observations made by the author during his visit to the fish-culture areas near Bandung are described.

18. ————(1937). Recherches concernant l'élevage de la carpe en rizières dans le nord de l'Indochine. *Compte-rendus des travaux de l'Institut des Recherches Agronomique et Forestières Indochinois*, **2:** 329—436, (in French).

Methods of preparation of rice fields in raising carps in the areas of Hàdông, Phuhô, Nghia-thuong and Son-tyâ in Tonkin, North Indo-China, are described. The rate of production and the size attained by carp are discussed.

19. Buschkiel, A.L. (1937)* Heat, Growth and Propagation in Tropical Waters. *International Revue der Gesamten Hydrobiologie und Hydrographie, Leipzig*, **35:** 21, illust, (in German).

20. Chacko, P.I. and Ganapati, S.V. (1952) Fish Culture in Paddy Fields. *Ind. Com. J.* (Madras), No. **8** (April): 3.

Fish culture in rice fields is state extensively practised in Japan, Thailand, Indonesia and other co of the Far East and recently att in the sugar and rice fields in Guiana and British West Indi India, in the deltaic areas Godavari, the Kistna and the and in the "Kole" rice fields o Malabar, fish crops, usually species such as snake-heads, spiny eels and young carps and m are obtained from rice fields. Re is made to raising prawns on scale in rice fields along the coast. It is recommended that on systematic lines can profit extended in the Madras State.

Mrigal, Rohu, Calbasu and Ch suggested as suitable species. Ramaswamy's opinion that by sive shifting from higher to low in terraced rice cultivation, the of the fish can be prolonged t months is cited.

21. Cheng, Tung-Pai (1953). The Cu Tilapia in Rice Paddies in *Chinese-Am. Joint Com. on Rura struction, Taipei. Fisheries Series* 1—29, illustr.

Directions for raising *Tilapia* fields, issued by the Chinese A Commission for Rural Recons are recapitulated, including field tion, fertilization, stocking a management. In connection last-mentioned item, mention is raising mud bunds to keep the fi marginal ditches off the main a planted rice until the seedl firmly rooted. South Taiwa warmer than North, is more fa for *Tilapia* culture in rice fields. of experiments in *Tilapia* cu fields three at Silo in the Prefecture are tabulated.

A decrease of 538 kg. in the ri per acre was compensated by a 303 kg. of table fish, besides s for future stock or for use as feed. Details of wintering p

given, are given, and the fish is recorded to have bred in one of them.

returns received to questionnaires issued by the Commission to prefectural and municipal governments in Taiwan, regarding the feasibility of *Tilapia* culture in rice fields, revealed that in about 40 per cent of the areas covered moderately successful results were obtained; in another 40 per cent the fish yield was affected by belated distribution of fry, and in 20 per cent. by floods.

About 740 metric tons of *Tilapia* is estimated from rice fields in Taiwan in 1952, as compared with 937.5 metric tons of fish from rice fields in all Japan in 1949. A note of caution is sounded that extension of Tilapia culture should not be rushed into without sufficient experimentation, planning and demonstration, so that disappointment due to hasty procedure might be avoided.

apelli, R. (1928). *Piscicoltura in Risaia* (Fish Culture in Rice Fields). Farion, G.B. Paravia, D.C., 74 pp. (in Italian).

A handbook on the importance of carp culture in rice fields, with descriptions of methods of fish culture and the economic results which can be obtained, with special reference to Italy.

mits, P. (1955), Methods of raising *Tilapia mossambica* in Rice Fields. *Tilapia* and its Culture. *FAO Fish. Bull.*, **VIII** (1): 16—17.

Conflicting views on the effect of Tilapia on the rice yield are quoted and the cultural methods in Tiawan, Thailand and Indonesia are briefly described. Cheng's (1963) and Ling et al's (1953) papers are among those annotated in the article.

mits, P. (1957). Methods of *Tilapia* Culture: *T mossambica* in Rice Fields. The *Tilapias* and their Culture. *FAO Fish. Bull.*, **X** (1): 9—10.

Tilapia mossambica which is an active feeder on green algae which compete with rice for nutrients, and the only species recorded to feed on *Euglena sanguinea* which often forms red layers in rice fields, has been used for culture in rice fields in Indonesia, Philippines, Taiwan and Ceylon. Ahjar's (1955) and Alikunhi's (1955) papers are among those annotated in the article.

25. Girard, M.J. (1956). Fish Culture in Rice Fields (Personal communication).
Fish Culture is practised in an empirical manner in rice fields in some parts of Spain, local carp being presumably used.

26. Goor, G.A.W. van de (1952). Rice Cultivation in Indonesia and its Relation to Fish Culture. Paper contributed to the *FAO Fish Culture Training Centre, Bogor, Indonesia*, 1—6, (in English)

27. ——————— (1955). Rice Cultivation in Indonesia and its Relation to Fish Culture. *FAO International Inland Fisheries Training Centre, Bogor, Indonesia*, Lecture 7.3 (mimeographed).

After describing the various systems of rice cultivation in Indonesia, the paper discusses the possibilities of fish culture in rice fields, quoting from the paper of Hofstede and Ardiwinata (1950). The author has come across no information of any harmful effect of fish culture or continuous flooding on rice. The relation of rice yield with (i) fertilization with superphosphate and (b) fish culture, is discussed. Suggestions for investigation to determine the effects of fish culture on the rice crop are offered.

28. Gopinath, K. (1955). Prawn Culture in the Rice Fields of Travancore-Cochin, India *Indo-Pacific Fish. Coun.*, IPFC/C 55/Sym. 18.

Thirteen per cent of the 35,000 acres of rice fields in the Cochin Kanayannur Taluq, 9.8 per cent of the 33,000 acres in Parur Taluq, 1.5 per cent of the 25,000 acres in Viakam Taluq and a small area in Shertalai Taluq are used for the prawn fishery which is common after the single rice crop (Pokali) season. Production in the regressive order is as follows: (i) fields adjacent to backwatersand subject to maximum tidal

influence, (ii) fields behind category (i) but intersected by brackishwater canals and (iii) fields farther away and yet under the brackishwater influence.

In addition to the usual prawn fishery during the rise of salinity in the fields after the rice harvest, an almost freshwater prawn fishery is met with in some fields two or three months after the rice is sown. The catches in this latter type of fishery are comparatively less. The field operations before, during and after the prawn fishery in the rice fields are also described.

29*. Green, C.F. (1928). *Annual Report on the Fisheries Department S.S.* and *F.M.S. for the year 1927, Singapore.*

30. Heath, R.G. (1934). Fish Production in the Krian Irrigation Area. *The Malayan Agricultural Journal, Singapore,* **22** *(4):* 186—189.

In the Krian irrigated area of rice fields, the Malay agriculturist derives an appreciable revenue from fish-sometimes as valuable as his surplus rice. The fish belong to the Anabantidae, Ophicephalidae and Siluridae. Wells of varying size associated with the fields enable the fish to retreat when water is drained from the fields as the rice ripens. Capture of the fish is also facilitated when they are thus collected in the wells. The habits of some of the species occurring in the fields are discussed.

31. Hiyama, Y. (1951). Rice-Paddy Carp Culture in Japan. *U.N. Scientific Conference on the Conservation and Utilization of Resources, New York,* **7:** 123—126 (in English).

Japan possesses about a millon acres of rice fields under water. 7,400 acres of these were used for carp culture in 1946, producing 3,794,000 lbs. of carp, i.e., about half of the total carp production in Japan. Methods of using rice fields as (i) hatcheries, (ii) nursery and growth grounds and (iii) rearing grounds of yearlings for successive years, are mentioned.

An annual carp yield per acre o by four to five months of cul Japanese rice fields is 130 lbs., can be increased nearly ten artificial feeding and additional

Work of plankton survey, r assessment of water and subs mutual effects of rice and fish density of carp stocking wi without artificial food and the of natural fish food in rice fie been attempted, but research i pursued. Good results are from rearing *Carssius aurat Misgurnus anguillicaudatus* in ric either alone or mixed with carps

The Government has countenan promotion of production in little areas under water, and owing to cost of artificial fish food in opportunities for rearing a cro natural biota abundant in the ri appeals to the Japanese.

32. Hofstede, A.E. (1948). Statement Netherlands on the Fishe Indonesia. *Proceedings of the Ind Fish, Coun.* (Sub-Area Com. Buitenzorg, Java).

It is mentioned that Tilapia co an excellent catch crop in fields and that it is sufficient to r the dykes and to concentrate more on the cultivation of Three methods of cultivat described.

33. —and Ardiwinata, R.O. Compiling Statistical Data o Culture in West Java. *Landbouw,* **22:** 469—494 (in English).

Tilapia mossambica and carp principal species cultivated fields. Two methods of cult described: (i) fish crop betwe harvest and the subsequent plan fish crop concurrent with the rice. Thirty to fifty kilograms estimated to be capable of being per ha. by the second method interval of 40 to 60 days betw planting and flowering. The rice is increased by about 7 per cent.

iwinata R.O. and Botke F. (1953). Fish Culture in Indonesia. *IRFE Sp. Rubl.*, No. 2:1—129, (in English).
Describes an experiment conducted to determine the comparative densities of incidence of mosquito larvae, especially of the malarial vectors, in rice fields with and without fish oulture.

ra, S.L. (1943). Paddy Cultivation cum Fish Culture. *Current Science*, Bangalore **XII** 169—172.
After citing F.A. Nicholson's observations made in 1907 about culture in Japan and in 1971 about the possibilities of such culture in the vast areas of rice fields in Madras, the author records an instance of utilizing rice fields for fish production in the "Abad" areas of the Sunderbans in Bengal. Suggestions for developing regular fish culture in rice fields in the Abad areas are offered. The economics involved, including the benefits of trench construction in the areas under agricultural reclamation, are also discussed.

——— (1943a). Paddy Cultivation and Fish Culture. *Indian Farming*, **IV:** 232-233.

———(1951). Fish Culture in Rice Fields. *Current Science*, (Bangalore,) **20** (7): 171—173.
On the evidence furnished (i) by Hofstede and Ardiwinata (1950), (ii) by De Vries, Bottemanne, Hiyama and Lin at the U.N. Scientific Conference on the Conservation and Utilization of Resources and (iii) by Pan in a personal communication, and citing the Proceedings of the 1948 Meeting of the FAO Rice Committee, the author advocates methodical fish culture in the vats areas of rice fields in the deltaic regions of India. The results obtained in paddy cum-fish culture set in operation in Bengal in 1945, are analysed. Better growth of Catla, Rohu and Mrigal in rice fields than in tanks is recorded.

——— and T.V.R. Pillay, (1954). Hand book on Fish Culture in the Indo-Pacific Region. Provisional Mimeographed Edition, FAO Rome.
The beneficial effects of fish culture on the rice crop, the three common types of culture in rice fields, water and soil conditions, biota, field preparations, stocking and management procedure and the economics of fish culture are discussed.

39. Indrasena, H.H.A. (1957). Final Report on Study Tour of FAO Fellow, 4 pp. (typescript). Discussing fish culture in rice fields in the Krian district in Malaya, the writer mentions that long-term rice which takes about seven months to mature, is planted in those fields, and water can, therefore, be maintained in the fields for six to seven months.

Commenting on the loss of about 50 per cent. of the stock of common carp in the rice fields of Hong Kong, due to predaceous fish, snakes and birds, he explains that such loss is marked when the predators concentrate on a small area of an acre or two and that loss will be proportionately less if the field is larger.

40*. Iyengar, H.D.R. (1953). Paddy cum Fish Culture. *Ind. Vet. Sci. Anim. Husb*, **23** (4) : 289—297.

41. Jacks, G.V. and M.K. Milne (1954). *An Annotated Bibliography of Rice Soils and Fertilizers.* Commonwealth Bureau of Soil Science, Harpenden Herts., England, and FAO, Rome, 179 pp.

Some of tbe 952 papers annotated deal with the problems of fertilization, incidence of algae and other ecological aspects of rice fields.

42. Kuronuma, K. (1954). Carp Culture in Rice Fields as a Sidework of Japanese Farmers. *Bull. Freshw. Fisheries Res. Lab. Fisheries Agency, Japan*, pp. i-ii and 1-29.
In addition to common carp, which is the chief item, wild and domesticated goldfish, *Carassius auratus*, the loach, *Misgurnus anguillicaudatus* and the ayu fish, *Plecoglossus altivelis* are raised in Japanese rice fields. A typical centre is seen at Nozawa town in the Saku plain. Statistics for the years 1949-52

on rice and fish harvested from the fields and on carp production by bodies of water are given. Conditions for carp culture in rice fields are enumerated. Culture operations are described with a discussion of the economics of carp culture in Japanese rice fields.

43. Kuronuma, K. (1955). Fish Culture in Rice Fields in Japan. *International. Inland Fisheries Training Centre, Bogor, Indonesia*, Paper IPFC—56—INC. 26, 9 pp. (Mimeographed).

About one quarter of the carp yield in Japan is stated to come from rice fields covering about 10,000 ha. The paper describes the operations by which the Japanese rice farmers use some fields as hatcheries and nurseries and others as seasonal rearing grounds. Before the fields are drained prior to the rice harvest, the fish are removed and the larger ones marketed while the smaller ones are kept in stock ponds and wintered in special ponds. These fish are subsequently reared again in the rice fields for one or more seasons as required.

44. Legendre, J. (1924). The Technique of Fish Culture in Rice Fields. *Bul. Société Centrale de l'Agriculture et de la Pêche*, **4—6** : 18 (in French).

45. ———(1928). Fish Culture in Rice Fields. *Riz et Riziculture*, (Lyons, France), **3** (2): 70—89, (in French); English Summary, pp. 90—91.

Advocating fish culture in rice fields as a means of malaria control and food production, the author briefly discusses the practice in Madagascar where *Paratilapia polleni*, *Carassius auratus* and *Cyprinus carpio* gave good results in rice fields. A week's delay after transplantation of rice is suggested before introducing the fish into rice fields. Fish fond of stagnant water, such as carps, are recommended.

46. ———(1938). Fish Culture and Poultry-raising in the Rice Fields of Madagascar. *La Nature*, Paris, 14 (11): 2 pp. (in French).

47. Le Mare, D.W. (1949). *Fisheries Depa Annual Report, Federation of Mala Singapore.*

Results of an experiment in 19 rearing 2,500 *Tilapia mossambic Helostoma temmincki*, and 45 *Osphro goramy* together in a sump pon beside a rice field and connecte the latter, showed that though spawned repeatedly, *Ophicephalus* had gained entry into the fiel thrived at the expense of the fish, indicating that the incide *Ophicephalus striatus* may be a li factor to the success of the cul fish such as Tilapia in rice fields.

48. Lemasson, J. and J. Benas (1942). on the Methods of Fish Culture i Fields in the Delta and the Centr of Tonkin.

Bul. Economique de l'Indochine, 6 : 49 pp., Bibliogr., (in French).

49. ———(1953). gramme de mise en valeur des continentales de Madagascar. Mi Ministère de la France d'Outre Paris.

50. Ling, S.W. and Sidhthimunka (1953) ture of Tilapia for Food and Bangkok, 7 pp., (Mimeographed). Besides other aspects of Tilapia c its use in rice fields is discussed.

51. Macdonagh, E.J. (1946). Pisoicult Pejerrey en el arrozal de la Facu Agronomia de la Plata. *Rev. Fac. La Plata*, **26** : 33—50, (in Spanish)

The growth and propagation of P (King fish), *Atherina bonarien* rice field experiments have bee satisfactory. Such culture hel production of food fish, which is than carp, and the control of m mosquitoes.

52. Matsui, Y, (1948). *Suiden Yogyo Field Fish Culture*, 166 pp., 26 te (in Japanese).

Kernan, D.L. (1951). Japan's Freshwater Fisheries. *National Resources Section SCAP, Prel. Study*, No. 68, Tokyo. 14 pp. (in English).

nnon, M.K. (1954). On the Paddy Field Prawn Fishery of Travancore, Cochin, and an Experiment in Prawn Culture. *Indo-Pacific Fish. Coun.*, **5** (II-III): 131—35. Results of a two-year study of the prawn fishery in rice fields adjoining the backwaters and canals near Cochin in South India and of short-term experiments in prawn and fish culture in rice fields are furnished. Though actual culture by rearing young prawns for 2—3 months was in vogue around Narakal some 25—30 years ago, the current practice aims only at trapping the prawn in the field with the incoming tide after the single crop cultivation of rice and fishing it during a favourable low tide.

About 11,000 acres of rice fields are estimated to be used for this purpose in the Travancore-Cochin area. *Metapenaeus dobsoni*, *M. monoceros* and *Penaeus indicus* make up practically the entire catch. Fluctuations in their proportions, size range, etc, have been recorded. The prawn-farming experiment indicated a yield of about 400 lbs. per acre. A post-prawn crop of mullet, chanos, pearlspot and other fish yielded a catch of about 350 lbs. per acre.

oretti, G. (1955). Le controle biologique exercé per la Carps sur les insectes des rizières. *Conseil Gênêral des Pêches pour la Méditerranée (GFCM) Proceedings and Technical Papers*, No. **3**: 179—185.

Although carp culture in rice fields does not completely eliminate certain fauna which, appearing in the fields, are injurious to rice and which are eaten along with other biota by the carp, it does help to keep the numbers of these fauna down to a level permissible for agriculture. It is stated that certain chemical processes are more efficient for their control and in certain cases preferable.

56. Nguyên-van-Liêm (1939). La pisciculture en pays Thai (Fish Culture in the Thai Country), *Bull. econ. Indochine*, **42** (3): 501—520 (in French).

    A description of the fish culture in rice fields and ponds in the Thai country: methods, species, production and also an account of the legends and religions of significance attached to fish culture.

57. Nicholson, F.A. (1917). Carp. Growing in Germany. *Bulletin of the Madras Fisheries Department*, **11**: 158.

    The writer recommends fish culture in the extensive areas of rice fields in Madras.

58. Pan. C.L. (1954). Growth Rate of *Tilapia* Fish. *Monthly Progress Report of FAO Rice Expert for August* (Typescript).

    An increase of 225.23 per cent. in weight and of 122.53 per cent. in length in 55 days is recorded in fingerlings of *Tilapia nilotica* and *T. zilli* of initial average weight 29.73 g. and length 11.64 cm., stocked in rice fields in Gemmeiza.

    T. mossambica of initial average weight 7.5 g. and length 4.5 cm., imported from Bangkok, showed an increase of 293.33 per cent. in weight and 314.38 per cent. in length in 23 days.

59. Pannikar, N.K. (1937). The Prawn Industry of the Malabar Coast. *Bombay Nat. Hist.* Soc., **39** (2): 3

60. ———— (1952). Possibilities of further Expansion of Fish and Prawn Cultural Practices in India. *Current Science*, **21** (2): 29—33.

    In connection with the suggestions for expending the culture of euryhaline species in the coastal lowland waters in India, the author refers to the prawn-culture practice in the rice fields of Travancore-Cochin, where young peneids and other biota are admitted along with tidal water into the fields and prawns trapped when the water flows out.

61. Piacco, R. (1938). Fish Culture in Rice Fields seen from the Standpoint of self-efficiency. *Il Giornale de Risicultura, Vercelli*, **28**: 4 (in Italian).

62. Piacco, R. (1955). Aspects techniques et économiques de la carpiculture en rizieres. *Gen. Fish. Coun. Medit., Proc. Tech. Pap.*, **3** : 225—32 (FAO Rome) C.G. P.M.

63. Saanin, H. (1955). Fish Culture in Indonesia in General. *International Inland Fisheries Training Centre, Bogor, Indonesia.* Lecture 5,67 (mimeographed), FAO Rome.

The paper describes how *Helostoma temmincki* and *Osteochilus hasselti* are bred in rice fields in Indonesia.

64. ——————(1957). Fish Culture in Rice Fields. *International Rice Commission Newsletter*, **VI** (1) : 25 –28.

The joint action by the IRC and the IPFC regarding fish culture in rice fields and the present stage of this activity in Australia, Burma, Cambodia, India, Indonesia, Japan, Pakistan, Philippines, Taiwan, Thailand, Malaya, Hong Kong, North Borneo and Arkansas are reviewed. The main fish-cultuarl, rice-cultural and socio-economic problems to be borne in mind in pursuing fish-cultural programmes in rice fields are enumerated.

65. Schuster, W.H. (1952). Report on the Possibilities for Fish Culture in East Pakistan.

FAO, (Rome), 22 pp. (mimeographed).

The report states that fish culture would be possible in the 20,193,000 acres under rice in East Pakistan, that carp and *Trichogaster pectoralis* are generally used in some of the rice fields and that *Tilapia melanopleura* could, after experimentation, be introduced in rice fields.

66. ——————(1952a). The Role of Extension Servioes in Inland Fisheries. *FAO Fish. Bull.*, **5** (2) : 41—55.

In connection with the development of extension services in inland fisheries, the principles and practices of fish culture in rice fields in different countries are discussed. The wild crop naturally appearing in rice fields is also re to. Since the basis, the milie principles and the methods of prod in fish culture are closely allied t in agriculture, the former, unlike fishing, should be regarded as an ag enterprise, and the extension s should be planned accordingly.

The economic structure and the tional level of the farmer should ally be borne in mind.

The organization and methods of fi extension existing in Indones detailed.

Cyprinus carpio, Carassius auratus, mossambica, Trichogaster pe Ophicephalus striatus, Clarias ba Anabas testudineus, Catla catla, rohita and *Cirrhina mrigala* are as fish cultivated in rice fields.

67. ——————(1952b). Develop Extension Services for Culture of Rice Areas.

International Rice Comm., (IR Session, Notes on Agenda Item 9—17, (mimeographed).

As in another article (1952a) by th author, the principles and pract fish culture in various countr discussed. The main reason f limited utilization of rice fields production is that the techni breeding and rearing fish are u outside the areas where fish cu an indigenous industry.

68. ——————(1954). Use of Ric for Fish Culture.

IRC 4th Session, Background Pap 54/7. 17 pp. (mimeographed).

Current views on the advanta disadvantages of fish culture fields are summarized and probl research are indicated.

More than dimensions of sw space, nutrient content of wat soil are stated to be significant cessful fish culture in rice fields.

Elevations from 150 to 1000 m. are most favourable from the points of view of topography, temperature, slope, drainage and pH. In mountainous regions, terraced areas as in the Preanger Highlands of Java, the Batak countries of Sumatra, the rice areas in Nepal and the Thai countries of Indochina are suitable.

Fish commonly propagated in the artificial manner, particularly the acid-resisting species, are to be preferred to self-propagating species for lowland rice fields and marshes. Shrimp and fish culture is possible in rice fields adjacent to brackish waters as in Bengal and Travancore, where the neutralizing effect of alkaline seawater is left and where fry and spawn occurring naturally in the irrigation water can be used for stocking.

In respect of climate and rainfall, fish culture follows the same borderlines as rice cultivation. The significance of sewage and the advantage of a handy fish crop in small holdings to be drawn upon in times of need are discussed with reference to Asiatic conditions.

Carp, with its capacity to use chironomid larvae, algae and other aquatic biota is the most productive species for culture in rice fields. *Tilapia mossambica*, which feeds on *Euglena sanguinea* and other algae which compete with rice for nutrients, can be raised with advantage along with carp.

After discussing the methods employed for fish culture in rice fields, the author points out certain drawbacks such as the reduction of rice area by trench and sump construction, requirements of water depth which some varieties of rice do not tolerate, and the uprooting of rice seedlings. Reference is also made, among other things, to Tilapia growing in rice fields in Haiti and Thailand.

Emphasizing the need for research on the different problems of fish culture in rice fields, a recommendation is made for the formation of a Joint Committee on Fish Culture in Rice Fields, representing the IPFC and IRC.

69. Schuster, W. H., G. L. Kesteven and G. E. P. Collins (1954) Fish Farming and Inland Fishery Management in Rural Economy *FAO Fisheries Study* No. 3, Rome, Italy, pp. 23-31.

Fish-cultural practices in rice fields and their yields in Indonesia, Japan, Malaya and India are reviewed. On the basis that yields varying from 3 kg. to 200 kg. per ha. are obtained annually by management of the wild crop alone in rice fields, it is estimated that a minimum total potential production of 240,000 tons per annum can be expected from the 80 million ha. of land producing the supply of rice. The introduction of rice and fish culture in Nigeria and Tanganyika is referred to. The benefits, of fish culture on the rice crop noted in Indonesia, Japan, China and Malaya are mentioned.

70. Soong Min Kong (1947).* *Preliminary Report on Sepa siam Investigations in Krian. Office of Special Commissioner in South-East Asia. Fisheries Conference Singapore. Paper No.* **9** *(mimeographed).*

71. ——————(1948).* Fisheries of the Malayan Padi-fields.–I: Sepat siam. *Malayan Nat. J.* 3 (2).

72. ——————(1949).* Fishes of the Malayan Padi-fields.–II: Aruan: Serpent Head Fishes. *Malayan Nat. J.*, **4** (1).

73. ——————(1950).* Fishes of the Malayan Padi-fields–III: Keli: Catfishes. *Malayan Nat. J.*, **5** (2).

74. ——————(1950).* The Fitness of Ecological Niches into which Fish are introduced at various Ages and the Survival of the Transplanted Fish. *Indo-Pacific Fish. Coun.*, **3** (II-III): 218-227.

From a study of the yield of *Trichogaster pectoralis* it is inferred that in the alkaline area near the sea coast, the fish fed on zooplankton and blue-green algae, and the yield was higher (200 to 400 lbs. per acre per annum) than in the acid area (10 to 15 lbs. per acre per annum) where it fed more on green algae (mosty) desmids and detritus.

75. ———————(1954). Fish Culture in Paddy Fields in the Federation of Malaya. IRC 4th Session Paper. IPFC Contributed Publ. IPFC/C55/CP 26, 5 pp. (mimeographed).

The fishery composed of *Trichogaster pectoralis* introduced from Thailand and four indigenous fish, viz., *Clarias batrachus*, *Ophicephalus striatus*, *Trichogaster trichopterus* and *Anabas testudineus* in the Malayan rice areas is described. Without any deliberate stocking in the fields proper, the fish which establish themselves and breed in the sump ponds, spread to the rice-field system and sustain the fishery. As the fields begin to dry up, the fish move back to the sump ponds through the irrigation drains and enable themselves to be harvested. In areas subject to torrential floods the rice-fields fishery does not thrive.

It is believed that *T. pectoralis* is beneficial to the rice crop in reducing algae which compete with rice for nutrients and in eliminating insect pests.

76. Tanh, K. (1949).* An Observation of Fish Culture in Rice Fields. *Bull. Jap. Soc. of Sci. Fish.* 15 (2) : 4pp. (in English)

77. Tonolli, V. (1955).* Carp Culture in Rice Fields. *Gen. Fish. Coun. Med. Proc. Tech. Pap.*, **3** : 151-159 (FAO, Rome).

78. Vaas, K. F. and A. E. Hofstede (1953). Studies on *Tilapia mossambica* Peters (Ikan mudjair) in Indonesia.

Contr. of Inland Fish. Res. Stn. Djakarta-Bogor, Indonesia, No. **1** : 1-64.

It is observed that, in Java, Tilapia is little used in rice fields because it yields a lower crop than carp, but the ease of its cultivation has made it popular where carp is not available.

79. Villadolid, D. V. and P. A. Acosta (1 Raising Tilapia for Food and *Department of Agriculture and N sources, Bureau of Fisheries,* N Philippines.

80. Voelcker, O. J. (1953).* Padi Prod in Malaya.

Conference Paper 13, *Report of a Con of Directors and Senior Officers of A ture held at Wye College, Kent, E September 1953. Colonial Office P tion, miscellaneous* No. 519.

81. Wyatt, I. J. (1956). Paddy Sten Investigations in Krian, Perak *Newsletters*, No. 20.

Laboratory experiments of ex young snake-head, *Ophicephalus s* to insecticides generally used fo trol of paddy stem-borer in Krian, Malaya, confirmed the results experiment conducted two yea viously, that Endrin (as 19.5 pe emulsifiable concentrate, 0.00045 and Dieldrin (as Dieldrex 15, pe 0.0079 p.p.m.) are too toxic to fish normal rate of application ($\frac{1}{2}$ to 1 acre), though Dieldrin may be saf the paddy is dense and little reaches the water. DDT (as 25 p emulsifiable concentrate. 0.04 p.p. Gamma-BHC (as i. Gammalin lic 10 per cent. gamma, approx. 0.7 and ii. Agrocide wettable pow per cent. gamma, 0.32 p.p.m.) w is stated, normally be safe to use.

The solvent oil is suspected to be tributing factor in the toxicity of ticides, while an unknown con of Agrocide wettable powder is b to have an antidote effect both fo ma-BHC and Dieldrin.

QUELQUES ESSAIS DE RIZIPISCICULTURE AU SUD-VIET-NAM

par

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ENGLISH SUMMARY

his is a trial on fish culture is paddy ducted in South Vietnam.

wo fields were chosen in two separate Phû-My and Thu-Dûc. Each field vided in three plots A, B, C. Plot A control plot where same quantity izer as in plot B was put in, Plots B and stocked with fish; plot C had a supple- fertilization (50% more than in plots).

uration of stocking was 150 days for and 130 days for Thu-Dûc.

Yield-per kg. ha. year were:

a) Fish yield (kg.) :

Phûmy : Plat A–26,028; Plot B–Plot C–54,000

Thu-Dûc : Plot A–17,168 ; Plot B–440,584 ; Plot C–265,014

b) Rice yield (kg.) :

Phûmy : Plot A–1.325; Plot B–1.584; Plot C–1.617

Thu-Dûc. : Plot A–1.620 ; Plot B–1.673 ; Plot C–1.710

No conclusion can be derived from these experiments. At Phû-My the population living around the experimental fields, contributed to errors in the results.

ABSTRACT

Si l'élevage des poissons dans les rizières est pratiqué depuis fort longtemps dans les ns hautes du Nord-Viêt-Nam par contre, il est présaue inconnu dans le Sud-Viêt-Nam.

Cartes, d'aucuns disent qu'il existe une rizipisciculture dans certaines régions du Viêt-Nam et citent pour exemple la Plaine des Joncs et les rizières de Camau. En réalité, ie l'on prend pour pisciculture en rizière ne sont que des étangs pièges où les poissons nturent dans les endroits herbeux et inondés pour chercher leur nourriture et pour frayer, retenus et capturés à la fin de la saison des pluies.

Dans quelques provinces de l'Ouest du Sud-Viêt-Nam, on élève en rizière des Tricho- r mais aucune méthode piscicole n'y est vraîment appliquée. On se contents de mettre ques paniers de Trichogaster dans la rizière où des fosses de refuge ont été creusées au lable pour permettre aux poissons de s'y réfugier dans les heures chaudes de la journée.

Ceux-ci se nourrissent, croissent et se multiplient à leur guise, la main de l'homme ntervenant aucunement, la Nature faisant tout. Si à la fin de l'élevage le fermier obtient bonne récolte, il la doit, affirme-t-il, au Ciel, à la Providence.

Bref il n'y a aucune litérature, aucune étude technique sur la rizipisciculture au Sud- -Nam, la présent communication a pour but de voir si les rizières du Sub-Viêt-Nam iennent à l'élevage du poisson, si elles peuvent donner à nos fermiers un revenu supplé- taire en poisson et si avec la pisciculture ces rizières ne verraient pas augmenter leur ement en riz.

CHOIX DU TERRAIN

Pour effectuer nos expériences, nous avons choisi deux rizières dans deux régions distinctes : Phûmy et Thudûc.

Phumy se trouvent à la périphèrie de Saigon, le terrain appartient à l'Office du Riz ; une population laborieuse ne trouvant pas de logement à Saigon même, habite tout le pourtour des parcelles objects de nos expériences ; nous verrons par la suite les conséquences de ce voisinage sur les résultats plus ou moins faussés de nos expériences. La Rivière de Saigon coule à proximité de sorte il n'existe qu'aucun ennui quant à l'irrigation du terrain mais par contre les risques d'introduction des poissons étrangers sont plus nombreux.

La rizière de Thuduc se trouve à une quinzaine de Km de Saigon parconséquent en pleine campagne, de plus elle est très distante de l'arroyo. Elle semble réunir toutes les conditions requises pour conduire l'expérimentation à bonnes fins.

L'analyse des deux terres donne les résultats suivants :

Detail de l'analyse	Rizière de Phûmy	Rizière de Thuduc
pH	4.20	4.5
P_2O_5 total	0.040 %	0.110 %
CaO total	0.130 %	0.140 %
K_2O total	0.086 %	0.102 %
$Al_2 (SO_4)_3$	0.077 %	0.097 %
P_2O_5 assimilable	0.014 %	0.039 %
K_2O assimilable	0.023 %	0.031 %

Le sol est très pauvre en chaux ; le phosphate semble déficient dans la terre de Phûmy.

DIVISION DE RIZIÈRES EN PARCELLES

Les deux rizières sont divisées en 3 parcelles de superficie à peu près égale. La parcelle A servira de parcelle témoin où la culture du riz se fera dans les conditions normales tandis que l'on procédera à l'élevage des poissons dans less parcelles B et C. La quantité d'engrais donnée aux parcelles A et B sera identique alors que la parcelle C recevra une quantité d'engrais supplémentaire é 50 % de celle attribuée aux 2 premères

RENFORCEMENT DES DIGUES E CREUSEMENT DES RIGOLES

Il y a lieu de surélever les digu rizières pour que les poissons empoisson puissent pas s'échapper et pour préveni l'intrusion de poissons étrangers. Seu parcelles B et C recevront ces travaux ratoires.

On procédera d'abord au creu d'une rigole tout en bordure des parcel rigole aura 0m40 de largeur et 0m40 fondeur.

Le déblai provenant du creusem cette rigole servira à consolider et s les diguettes bordant les parcelles. Ap travaux, les diguettes auront une haute forme de 0m60. Le creusement d'une f refuge ne s'avère pas nécessair car la hau l'eau, une fois les plants de riz en place, dra 0m60 dans les rigoles et 0m20 d endroit les plus hauts.

Les frais occasionés pour les préparatoires sont assez minimes. Ils nent à 50 $ V.N. le mètre cube de terre (soit 1,43 $ U.S.). Ce prix compren la confection de la diguette.

Empoissonnement :— Nous n'avon choix sur les alevins à mettre dans les car les Stations piscicoles ne produiser espèces : le Tilapia et la Carpe. La pr de cette dernière étant insuffisante à s les demandes des fermiers, nous somm obligés de prendrep our les essais, des al Tilapia que nous produisons en abondan

Le nombre, la taille et le po alevins sont pris au hasard et ne suiven règle déterminée. Ils dépendent beauc des disponibilités des Stations piscicol

La mise en charge des rizières généralement le matin de bonne heu éviter less effets néfastes du soleil alevins toujours fragiles. Elle a lieu 15 jours après le repiquage des plants d délai nécessaire pour que les plants d deviennent robustes.

s parcelles B et C reçoivent des
ceux-ci se débrouillent dans la rizière.
nourriture supplémentaire leur est

RÉSULTATS

durée de l'élevage n'est pas la même
2 rizières. Elle est de 170 jours à
130 jours à Thudûc. Elle dépend de
té plus ou moins longue de l'espèce
cultivé.

s rizières sont vidées de leur eau avant
nnage. Il y a lieu de laisser sortir
t l'eau de la rizière pour que les pois-
nû le temps de quitter les endroits
de se réfugier dans les rigoles où
pêchés aisément.

s tableaux I, II et III donnent le
r l'empoissonnement et la pêche des
de chaque parcelle d'expérience.

convient de noter ici quelques remar-
i se retrouvent dans les 2 champs
nce.

)— Dans toutes les parcelles, on trouve
ions étrangers en général tous préda-
Ceux dont la taille dépasse 10 cm. de
t des ophiocéphales et des poissons
ndis que ceux de taille inférieure à 10
des anabas mêlés à quelques Tricho-
anctonophages.

)— On ne trouve pas d'alevins de
de 3 a 5 cm. malgré la longue durée
age contre toute attente la quantité
est inférieure à celle mise en charge.
les Tilapia se reproduisent dans les
mais leurs petits sont probablement
par les poissons prédateurs qui en font
ent essentiel.

)— Le rendement en paddy des par-
est supérieur à celui des autres
s. Ceci est dû à l'apport supplémen-
engrais.

es résultats obtenus dans les rizières de
ne permettent pas de tirer des con-
évidentes. La parcelle B malgré l'im-
de la quantité de poissons empois-
lonne un résultat négatif. Le rendement
rcelle C est aussi médivocre.

Il est probable que les résultats ont été entièrement faussés par les pêches clandestines des habitants riverains de la rizière et aussi par le nombre excessif des prédateurs.

Quant aux expériences de Thudûc, elles présentent une anomalie étonnante. La parcelle B qui a reçu moins d'engrais que la parcelle C obtient cependant un rendement en poissons presque double de cette dernière.

Lors de la mise en charge de la rizière, nous avons omis de faire un dénombrement des alevins par leur taille mais nous inclinons à croire que sur les 3.595 alevins empoissonnés, il y a au moins 2.500 alevins présentant une taille de 3 à 5 cm. car à la pêche nous retrouvons ce chiffre dans la catégorie des poissons ayant une taille de 10 à 15 cm.

Ceci revient-il à dire que le meilleur rendement serait obtenu en partant d'alevins de taille inférieure à 5 cm.

En résumé, les expériences conduites à Phûmy et à Thudûc donnent des résultats assez décevants.

Les chiffres donnant le rendement en poisson et en riz par hectare et par an sont tels que nous ne puissions faire aucune hypothèse logique.

Conclusion.—

Au cours de nos expériences, nous avons à surmonter et à résoudre certaines difficultés parfois insolubles.

Les rizières du Sud-Viêt-Nam dépendent essentiellement pour leur culture, de la pluie. Dépourvues de relief, elles ne se prêtent pas au système d'irrigation savant et compliqué dans lequel l'homme, maître de l'eau peut a sa guise, diminuer ou augmenter le volume de celle-ci ou même assécher complètement une terre. C'est pour cette raison qu'il est parfois difficile de conserver l'eau dans les rizières quand la pluie se fait rare. Il faut avoir recours au pompage, moyen trop couteux pour la masse paysanne.

De plus, les terres du Sud-Viêt-Nam sont en général très alunées, le pH descend parfois jusqu'à 4. Dans ces conditions, la pisciculture et à plus forte raison la rizipisciculture ne peut se développer convenablement à moins qu'on y fasse un grand chaulage. Or, cela demande beaucoup d'argent.

D'autre, part, l'empoissonnement des rizières innondées aptes à l'élevage demande une quantité considérable d'alevins que nos stations d'alevinages ne sont pas à l'heure actuelle suffisamment outillées pour produire et distribuer.

Enfin, les poissons obtenus atteignent une taille bien inférieure à la taille marchande demandée par le consommateur.

Quoiqu'il en soit, nous ne devons pas nous empresser de faire des conclusions hâtives tendant à condamner ou à minimiser l'élévage des poissons dans les rizières.

Les expériences doivent être pour et même multipliées dans toutes les cat de sol et échelonnées pendant au moi décade.

Le rassemblement et la centralisa tous les résultats obtenus dans les dive du Sud-Est asiatique permettront de f une opinion précise sur la matière et être, de résoudre des problèmes spécifi chaque contrée.

Tableau I. Montrant les résultats de la pisciculture dans les rizières de Phû-Mỹ.

Lieux d'exp´rience	Superficie	Empoissonnement				Récolte en poissons				Rendement par kg./ha./an.	Récolte en paddy en kg.
		Date	Nombre	Taille en. cm.	Poids en kg.	Date	Nombre	Taille en cm.	Poids en kg.		
Parcelle A	9.500 m^2.	—	—	—	—	27.2.57	26	15-20	4.800		
							31	10-15	4.200		
							108	7-10	3.300		
							165		12.300	29,520	1.325
Parcelle B	10.000	1.10.57	3.544	10-15	40.600	,,	5	20-25	1,600		
				3-5	26.000		263	15-20	45,000		
					66.600		61	10-15	9,200		
							87	7-10	2,700		
							416		58,500		1.584
Parcelle C	6.300	,,	2.340	10-15	37	,,	2	20-25	0,800		
				3-5	18		176	15-20	30,100		
					55		520	10-15	28,400		
							73	7-10	2,700		
							771		62,000	40,800	1.078 soit 1,617 par ha.

Tableau II. Montrant les résultats de la pisciculture dans les rizières de Thû-Dûc.

Lieux d'expérience	Superficie	Empoissonnement				Récolte en poissons				Rendement par kg./ha./ an.	Récolte en paddy en kg.
		Date	Nombre	Taille en cm.	Poids en kg.	Date	Nombre	Taille en cm.	Poids en kg.		
Parcelle A	10.000 m^2.	—	—	—	—	25.1.57	6	15-20	1.000		
							46	10-15	2.500		
							71	7-10	2.700		
							123		6.200	17,168	1.620
Parcelle B	10.500	18.9.56	3.595	6-8	7,300	,,	3	20-15	0,700		
				3-5	30.000		238	15-20	44,000		
					37,300		2515	10-15	150,900		
							30	7-10	0,800		
							2786		196,400	440,584	1.673
Parcelle C	6.500	,,	1.342	3-5	5,700	,,	8	20-25	1.900		
							186	15-20	28,000		
							690	10-15	37,000		
							67	7-10	2,600		
							951		60,500	265,014	1.140 soit 1.710 par ha.

Tableau III. Montrant le nombre la taille et le poids des poissons sauvages capturés dans les parcelles d'expériences.

ix ience	Poissons élevés			Poissons sauvages			Observations
	Nombre	Taille	Poids (kg.)	Nombre	Taille	Poids (kg.)	
mŷ							
lle A	—	—	—	26	15-20	4,800	
				31	10-15	4, 2	
				108	7-10	3,300	
				165		12,300	
lle B	236	15-20	45,000	5	20-25	1,600	
				61	10-15	9,200	
				87	7-10	2,700	
				153		13,500	
lle C	176	15-20	30,100	2	20-25	0,800	
	465	10-15	23,300	55	10-15	5,100	
			53,400	73	7-10	2,700	
				130		8,600	
Dûc							
lle A	—	—	—	6	15-20	1,000	
				46	10-15	2,500	
				71	7-10	2,700	
				123		6,200	
lle B	238	15-20	44,000	3	20-25	0,700	
	2467	10-15	147,100	48	10-15	3,800	
	2705		191,100	30	7-10	0,800	
				81		5,300	
lle C	186	15-20	28,00	8	20-25	1,900	
	638	10-15	33,100	52	10-15	3,900	
	17	7-10	1,400	50	7-10	1,200	
	841		62,500	110		7,000	

REPORT ON THE SYMPOSIUM ON FISH CULTURE IN RICE FIELDS

THE SYMPOSIUM WAS CONVENED By Mr. M. Ahiar (Indonesia) at 09.40 hrs. 20-5-57.

he Rapporteur was *Dr. G.R. Fish (U.K.)*

he convener introduced the subject with account of its growing importance in the member countries. He then called *r. R. O. Ardiwinata* (Indonesia) to pre- comprehensive account of fishculture fields of Indonesia (SYM. 1) *Mr. H.* Indonesia) was appointed by the author esman.

he history of this practice in Indonesia iewed together with an account of the eld in recent years. The fish culture in the various districts from crops that avested of fish casually introduced into ded fields to those crops of fish, carefully l and grown simultaneously with the p. The availability of water limited the to which fish culture was practised in areas. In those cases where the rice ere utilized for the rearing of fry, a few sh were often introduced in order that dable fish food could be used to advantage. of the fish commonly cultured were given r with those combinations that had most profitable. The pests that may the yield of fish were noted. The ferti- and manuring of the fields frequently the stocking rate of fish if the fullest ge is to be taken of the potential fish ailable. The influence of land property culture in paddy fields was evaluated tails of the economic structure of this e were given by in some instances. It ted that, as a result of the activities of present, the rice yield was increased up other results being that the amount of weed was frequently reduced and hence mber of suitable breeding sites for the to.

bdoessamad Djaingsastro. (Indonesia) resented his paper (C.P. 38) on "Paddy ilkfish culture". This paper dealt with creasing value of *Chanos* and *Puntius* in coastal rice fields in Eastern Java.

The yield of fish from this culture has ed considerably since 1954 and is likely to be expanded further in the near future. The cash balance sheet from an experiment on this type of culture was given as an example of some advantages gained from this practice. Further profit and expenditure details are being examined in order to assess these advantages more precisely.

Dr. K. Kuronuma. How is the increase in rice crop estimated?

Mr. H. Saanin. The "Latin Square" system is used wherever possible with sample plots of 10 m. sq. These are harvested separately and the grain compared for weight and quality.

Mr. Cao Thien Buu. The use of a 10 m. sq. may be inadequate. In Viet Nam, test plots are of the order of 1 hectare.

Mr. H. Saanin. Commercial fields are used here and owing to the necessity for adhering to standard methods in harvesting for research purposes, relatively small samples only can be handled. The 10 m. sq. plot system is, however, recommended by the Central Office for Statistics. The data on harvests are found on P. 43, SYM. 1.

Dr. G.R. Fish. Have investigations been made regarding the most suitable strain of rice plant for the combination of fish culture and rice growing?

Mr. H. Saanin. Many rice strains are found unsuitable for this culture. Pre-war work on selections is now out-of-date and research is actively proceeding on this aspect of the problem.

Dr. K. Kuronuma. Experiments in Japan on the testing of various strains of rice for combination with carp culture have not yet shown any clear result.

Dr. A.M. Rapson. For how long was the growth of mosquito larvae retarded?

Mr. H. Saanin. Usually no larvae are found up to a period of 90 days. Afterwards, larvae are present in both stocked and unstocked ponds.

Convenor. There are clearly many unknown factors to be identified in this connection.

Dr. K. P. Vaas. SYM. 1 only deals with the conditions found in Indonesia. In other countries, the conditions of growth and the local mosquito species will be different.

Mr. Gelar Wiraatmadia. There are at least 3 common species of Anopheline mosquitoes in Indonesia, located at sea level *(A. ludlowi)*, about 300 metres *(A. aconitus)* and about 800 metres *(A. maculatus)* respectively.

Convenor. It is essential for more data to be collected in respect of other countries in order to assess progress made in the control of mosquito breeding. Is fish culture in rice fields practised in Hong Kong?

Mr. Yu Yat Sum. Experiments, started in 1948, have recently been stopped. Local demand is for a large fish and, as rice has a growing period of only 150 days, fish culture is difficult. In addition, the many predators on the fish could not be controlled satisfactorily and the supply of water is often severely restricted.

Mr. C. Martin. Similar difficulties, including unsuitable strains of rice plant, have limited the usefulness of this practice in the Philippines.

Mr. H. Saanin. Fish of 30 grams and upwards are used for consumption here. We therefore find that as little as 4" of water is sufficient for fish culture.

Mr. Gelar Wiraatmadja. An appreciation of rice cultivation, which is naturally the major crop, is essential. All fishery officers hold a diploma in Agriculture in Indonesia.

The Convenor then requested Dr. A. L. Tester (U.S.A.) to introduce SYM. 2 "Food-fish farming in the USA." by *M.C. Johnson* and *V.E. Davison*.

In America, work by *H.S. Swingle*, in particular, has stimulated interest in fish culture. The species cultured are mainly sporting such as Bass, Sunfish Buflalo, etc. The rice fields are very large and machine-cultivated. Intermediate crops, including fish are grown on a biennial rotation with the rice. In preparing land for rice growing, it is the practice to first flood the area for one or two years. This kills the trees and other terrestrial vegetation present. A fish crop is usually taken during this period also.

Dr. Kuronuma. At what temperature grown in the U. S. A.?

Dr. Tester. Rice is grown in the Southern which have summer temperatures up to and dropping occasionally to freezing in the winter.

Dr. A. M. Rapson. What height are the for these large fields?

Dr. Tester. I have no precise informa present on this point.

Mr. H. Saanin. Information on pract USA are included in the review to th Field Commission at Calcutta in 1956.

Convenor. I will request that copies review be distributed to active wor this field.

The Convenor requested Dr.K. Ku (Japan) to introduce SYM. 3 "A prel experiment on Agriculture Insecticid rice paddy fish culture" by *Y. S. Kimura* and *M. Tamakawa*.

Rice crops are often heavily i and insecticidal control measures hav taken. It is possible, however, that th in this connection is more frequent in fact necessary. These poisons af only the fish within the paddy area outside, as a result of drainage. S monly used insecticides were investiga in the field, using paddy already sto caged fish, and in the laboratory. It wa that the use of these insecticides low final yield of fish in all cases and that and Endrin were extremely toxic at trations normally used for pest contro

Mr. E. H. Dahlgren. Thousands of tons drin are imported into Indonesia. Co experiments should be made on all cides in conjunction with fish spe economic impostance. Where ne warnings should be publicized.

Dr. K. Kuronuma. Experiments on s insecticides and many fish species are The above report is only preliminary.

Mr. E. H. Dahlgren. Minimum lethal determined by laboratory experiment be the same in the field as in the la although due to absorption by detritu

ities of insecticides may be required to
e this minimum lethal dose.

or. It is important to have data on the
of insecticides on overall rice yield as
ct from their lethal effect.

Saanin. Fish mortality frequently occurs
anti-malarial spraying. Experiment has
that I. p.p.m. of Derris powder is lethal
ny fish species. Unfortunately, samples
ot available for further investigations.

or. In my experience, it is normal prac-
or field officers to arrange for a suspen-
of spraying in areas whilst fish culture is
ogress.

H. Dahlgren. Which insect-eating fish
ffective in rice fields?

Saanin. Although Tilapia is not an
t eater, it affects the breeding of mosqui-
by clearing the water surface and thus
ing the number of suitable breeding
. Many species of fish have been inves-
d in Indonesia in this connection and
in of them now recommended by the
ries Department, in particular *Panchax*
ax. The convenor emphasized that on
uestion of insecticides, a clear and simple
tive, based on sound scientific experi-
, was required. He then requested Dr.
. Fish (U.K.) to introduce SYM. 5
ckish water paddy-fish culture in West
al" by T.V.R. Pillay and B. Bose.

In this area, the practice of growing fry,
ght in by the estuarine and sea water
ing of fields, is widely and successfully
ised. The salinity, to which the fish
addy are subjected, varies widely from
ically zero to over 30 $^{0}/_{00}$, depending on
uration and extent of the S.W. Monsoon.

Salt resistant strains of rice are used and
fish cultured belong to many species
nding on the population of fry in the sea
e time of flooding. The more important
ese species are the mullet and prawns.
authors concluded that if the stocking
more closely controlled, it is probable
this farming system would be more pro-
le.

nor briefly discussed SYM. 6, Fish Cul-
in Rice Fields a review of literature
ared by FAO. He recommended this to the sub-committee which has been formed to report on this subject.

Convenor then requested *Mr. Cao Thien Buu* (Viet Nam) to introduce SYM. 7 "An account of preliminary experiments on rice-fishculture in South Viet Nam". The experiments were carried out in response to a request from Dr. Miles of FAO. Two areas were selected for the experiment. In each area, the fields were prepared by ditching to a depth of 40 cm. Three levels of fertilizing were used and the fields stocked with Tilapia. The results were somewhat confused by the action of indeterminable factors. These include large-scale predation together with infertility and acidity of the soil. The fish harvested were small in size and well below the minimum accepted by the consumer. However, valuable experience was gained for the prosecution of further experiments.

Convenor then requested *Dr. K. F. Vass* to indicate the present position regarding the culture of fish in rice areas.

Dr. K. F. Vass. Two main features of this problem have become apparent from our discussion to-day. Firstly, the enormous difference in scope and development of these fisheries between the various countries. In some cases, highly developed and complex systems are followed and in others there is little progress, Secondly, although many data have been presented, few of the basic principles have emerged which must control the success of this culture. The great value of the symposium to-day has been to show where further work is needed to elucidate these principles. The culture, broadly speaking, can be divided into 2 main systems, captural and cultural—In captural systems, no selective stocking is carried out but the fields are used initially to trap wild fish which are then cultured and harvested. Such methods may be used anywhere where wet paddy is grown and in many areas, this is the only method used. In fact, where there are large fields, as along sea and river coasts, this is perhaps the only feasible one. In the case, however, of small bunded paddy fields, the practice can go a step further and the field can be used as a fish pond. The possibilities of this depend on certain considerations such as availability

of fry for stocking and the method of cultivation that is followed for the rice crop. There is little doubt that relatively slight changes in the purely agricultural methods for rice growing, will enable the full potential of the field as a fish pond to be easily realized. The changes concern the height of bunding, manuring routine and the followiug procedure. The size of the fish harvested must be closely related to the local consumer demand and this, together with the availability of water, will control the decision as to the initial size of the fish stocked. The importance of the cash profit on the fish grown, as related to property control and values, deserves careful consideration as also does the public health aspect, in view of the position of the m as a vector of malaria.

Convenor thanked Dr. Vass and indica considerable value of the contribution verbal and written, that had been r during the Symposium. This was of pa importance as a guide to the work p for the working group that has been to investigate fish culture in Rice Fiel contributions were gratefully acknowle the *Convenor* in his capacity as chair this working group.

Convenor declared the Symposium at 17.00 hrs.

Price: U.S. $1. Obtainable from Publications Section, FAO, Rome, Italy, or I.P.F.C. Secretariat, F.A.O. Regional Office, Bangkok, Thailand.